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EDUCATION AND COLONIAL DEVELOPMENT

A LONG series of reports on almost every aspect of welfare in the British Colonial Empire, quite apart from the quiet but increasing work of the Colonial Research Committee, the Colonial Products Research Committee and other committees concerned with Colonial research in different fields, and more recently of the Colonial Primary Products Committee, have brought many scientific men into close touch with the particular economic, social, scientific and technical problems of these great areas. In the last ten years there have been important general surveys of nutrition, higher education, labour conditions, development and welfare ; and also studies in more limited fields such as cocoa control in West Africa, West African oils and oilseeds, the groundnuts scheme in East and Central Africa, the advancement of Africans in industry, and the relation of the game reserves to the slaughter of game, with all of which the man of science is more or less directly concerned. Quite recently, it has been announced that medical specialists from a panel of eighteen will each visit Africa twice in the next six years, and if the experiment, which is being financed by the Nuffield Foundation, is successful, it may be extended to other territories.

Precedent for this unofficial contact is to be found in an earlier visit of university representatives to Nigeria, under the same ægis, or again in Service medicine during the War ; scientific workers who have had personal contact or experience with any of these developments may well have been impressed with the way in which Great Britain is facing its responsibilities under the Colonial Development and Welfare Act. Mr. Marquand's recent tour of the East African Colonies is further evidence of the keen interest of the Government in Colonial welfare and development, and of the sincerity of the desire to promote self-government as well as a high standard of living in the British Colonial Empire.

It should not be necessary to do more here than mention the immense potentialities which science itself holds for the promotion of welfare in the Colonies, by the control of or even elimination of disease, the raising of nutrition standards, the improvement of agriculture and production, either by the introduction of more efficient methods or the control of pests of plants or animals, or by extending man's command over natural resources by irrigation and like methods.

Some of the recent advances in such fields promise really spectacular developments in the control or elimination of tsetse fly and other pests, with most valuable results from the point of view of health and economics alike. Nevertheless, even the man of science responsible for such advances can scarcely fail to note the signs of widespread discontent with existing conditions. The disorders which occurred in the Gold Coast early in March and arose out of the serious increase in the cost of living in West Africa, and the evidence of fundamental discontent among

the intellectuals in the West Indies which finds violent and extreme expression in the report for 1942–43 of Dr. T. P. Achong, the Mayor of Port-of-Spain, Trinidad, are symptoms of a cynicism and disbelief in British policy and intentions which cannot wisely be disregarded. Inevitably they raise questions about the functioning of democracy among the Colonial peoples, and how best these peoples are to be fitted for self-government.

The contemporary review of British, United States, French and Dutch policy and practice in their Caribbean possessions which Paul Blanshard has written under the title "Democracy and Empire in the Caribbean"* is of interest from that point of view. The picture of the British West Indies as seen through American eyes is instructive, if sometimes a little crude, unimaginative and intolerant; but the comparative appreciation of the practice of the four Colonial Governments is fairer than some of his criticism, and beyond that he displays plainly the fundamental aspects of the situation in the Caribbean. This book makes very clear the background against which the Colonial research committees have to work, and in particular the limits which economic, social and political factors set to the work of the Caribbean Research Council.

Many will think that Mr. Blanshard takes too pessimistic a view of the prospects of regionalism and of the future of the Caribbean Commission; some of his criticism leads naturally to such pessimism. None the less, his forecast of the future may well be near the mark, for in it he seems to shed some of his prejudices. He believes that for most of the Caribbean colonies, independence is undesirable and undesired by the people themselves; but he urges that the first step in political progress is to make all legislatives genuinely democratic, and that next the governors should be elected by the people or their elected representatives. He admits, indeed, that in some areas the people are obviously unready for this step, and that when it is taken safeguards will be required for the standards of the Civil Service; clearly his criticism of the present system is not to be taken entirely at its face value.

Next, the colonies of the Caribbean should be fitted into a democratic regional agency with power to co-ordinate and develop the economic life of the area, and serve as a link between the region and world organisation. He would place all these colonies under the Trusteeship Council of the United Nations, giving the Council full power to investigate and report upon all aspects of Colonial administration. Here again he admits that his proposition has no immediate hope of realization, and he further recognizes that all his political proposals demand universal, free and compulsory education for a generation as preliminary preparation for self-government.

In the economic sphere, he says little about the question of nutrition and raising the standard of living, though he recognizes a trend in the area towards increasing social control of economic life and the need to maintain the large-scale plantation system, regardless of the type of land ownership, because of the greater productive efficiency of large operating units. He has little to say about the contribution of science to the social welfare or economic progress of the area, though, surprisingly in view of much of his criticism, he concludes on the note that the Caribbean peoples will remain loyal to the Western democracies, provided that those democracies be worthy of their allegiance.

Mr. Blanshard's book should certainly dispel any complacency with which British rule in the West Indies is regarded, or even the operation of the Colonial Development and Welfare Act. There is, however, a wealth of material against which the objectiveness of his criticism can be tested, and it is to be hoped that his book will stimulate at least some scientific workers to make that effort. What stands out most clearly is the need for much closer and objective study of the working of democratic institutions among the Colonial peoples, and the means by which the idea of true local self-government may best be furthered in terms of the economic, social and cultural as well as political welfare of those peoples.

Mr. Blanshard, although at times excessively caustic in his comments upon governors in the Colonial systems, is not so obsessed with his dislike of that system as to fail to recognize that the strongest indictment of the Colonial Powers in the Caribbean is that for a hundred years after emancipation they did so little to prepare the people for self-government, and that the Caribbean peoples were not given a fair chance to learn democracy by practice. Nevertheless, his survey makes little constructive contribution as to the way in which that problem of education is to be tackled, and for all its merits as a comparative study of different systems and as a guide to the trend of local opinion—in which last a bibliography and some notes and comments on Press articles are useful further aids—his book of three hundred and seventy pages, so far as education is concerned, falls far short of the forty-page report on "Education for Citizenship in Africa" which has come from the Colonial Office Advisory Committee on Education in the Colonies (London: H.M.S.O. Colonial No. 216, 1948. Pp. 40. 9d. net). It might be objected that the sub-committee responsible for the report should have included a representative of the Colonial administrators on whom will fall the main burden of providing the appropriate political and economic organisation, and some Africans whose presence might have added to its authority. No such additional representation could well have improved on its statement of general principles, or increased its consciousness of the necessity of preparing not merely Africans but also other Colonial peoples for self-government, and affording them the opportunity for its practice.

Under its terms of reference, the sub-committee was to study the technique needed to prepare people for responsibility, and examine generally the problem of building up a sense of public responsibility, tolerance and objectivity in discussion and practice, and an appreciation of political institutions, their

* Democracy and Empire in the Caribbean: a Contemporary Review. By Paul Blanshard. Pp. xi+379. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1947.) 25s. net.

evolution and progress. It was decided, however, to prepare a report which, though taking Colonies outside Africa into consideration so far as possible, should frankly apply principally to Africa, where its members had principally gained their Colonial experience. Speaking of the title of the report, the Committee emphasizes that there is no true education which is not education for citizenship, and that education which does not produce good citizens has not justified its claim to be called education at all. It is in this spirit that the Committee faces the central purpose of British Colonial administration, which has been described by successive Secretaries of State for the Colonies in similar terms, namely, to develop the Colonies and all their resources so as to enable their peoples speedily and substantially to improve their natural resources and, as soon as may be, to attain responsible self-government.

Self-government, however, is a much heavier responsibility in the twentieth century than in the eighteenth, and in pointing out that education must aim at fulfilling the special needs created by social and political changes and that with the great variations in culture, in social and economic conditions in the Colonies the path to self-government can scarcely be the same for all, the Committee affirms its belief in the soundness of the principle, which has guided British Colonial education policy in the past, that education to be effective must be based partly at least on local conditions. Not only must it take account of cultural differences; it must equally seek to present to the Colonial peoples Western civilization at its best side. The Western world should place its political experience of democracy and its conception of democratic government at the disposal of the Colonial peoples without any reserve. It will be for them to make what use they think fit of this experience. We must remember that democracy is not merely a matter of political institutions but of the spirit in which they are worked; democracy must arise from within, though it may be helped or hindered from without, and it can only be judged by being seen in action.

It is in dealing with the difficulties that exist in the path of the Colonial peoples who are endeavouring to advance towards full citizenship of the modern world that the report is so much more realistic than Mr. Blanshard's book. There is no less sympathy with, or understanding of, the aspirations of nationalism; but the disintegrating influence of Western civilization is more fully appreciated. The prerequisites of democracy are clearly stated: a profound belief in the value of the individual, and with it a general feeling of confidence in one's fellow citizens; the intellectual equipment—not merely informed minds, but minds capable of straight thinking and not to be deceived by the demagogue; and a political and economic organisation which permits such spiritual and intellectual qualities to flourish.

Much of the report is occupied by detailed recommendations, throughout which runs one main principle already adumbrated: you cannot educate people for citizenship unless you give them the chance of exercising their citizenship. For this reason the Committee urges that every opportunity should be taken of entering into full and frank discussion with the Colonial peoples while policy is still only half-formed and even if no formal organisation exists for such discussions. The importance is emphasized of bringing together around the council table the young educated men and the traditional elders; and that any tendency to restrict discussion on the plea that the people are not yet able to understand the questions involved is shirking the task of education for citizenship.

The report urges in conclusion that the task is too great to be left to one section only of the Government organisation, or of the European or educated Colonial public. The task is so large and urgent that the help of everyone will be needed, and in one section of the detailed recommendations, dealing with the teaching of science, the Committee shows how the man of science can help. It suggests the study of science from the historical point of view, with a background of its social implications and an indication of the indirect contribution to education for citizenship which training in science in this way can make. No constructive educational policy can ignore the dangers of producing a class of men of mainly academic training larger than can find a useful place in the body politic, and of neglecting the improvement of craftsmanship. One sound reason for welcoming such developments as the groundnuts scheme in East Africa is the increased outlet it might afford for African craftsmen and technicians; and for that reason alone the unexpected difficulties and greater cost of the scheme should not be allowed to exert undue influence. Similarly, while we may welcome wholeheartedly the recent recommendation for an institution of full university standing in Malaya, neither there nor in the West Indies nor in Africa should it be forgotten that with economic and industrial and educational development must go a careful study of the social-psychological factors which underly the rising tide of nationalism and have provoked the disorders on the Gold Coast and elsewhere. The full inquiry already promised into the Gold Coast riots, for example, should establish the facts; but something more is needed. Fundamental research into the real causes of Colonial discontents is a matter of the greatest urgency, not merely to point the way to appropriate remedial measures, but also to assist in the adjustment of our own attitude to the Colonial peoples. Collaboration with other peoples is imperative not only for the development and welfare of those peoples, but also to enable them to make that contribution to the welfare of mankind at which Mr. Bevin hinted in a memorable speech early this year; and collaboration involves mutual understanding and trust. The proposal for the establishment of a University of Malaya is much more than a further token of our goodwill and of our determination to build a noble structure of higher education in the Colonies. It is equally important as one more step towards the provision of institutions where fundamental research can be prosecuted, and where the Colonial peoples may learn the technique of research

in many fields where it is so urgently required. In that way and in co-operation with their Western teachers they may make their own distinctive contribution in advancing knowledge, and also gain the vision and wisdom which will increasingly fit them for the searching responsibilities of full self-government.

APPROACHES TO SOCIOLOGY

From Max Weber

Essays in Sociology, translated, edited and with an Introduction by H. H. Gerth and C. Wright Mills. (International Library of Sociology and Social Reconstruction.) Pp. xi + 490. (London: Kegan Paul and Co., Ltd., 1947.) 21*s*. net.

The Analysis of Political Behaviour

An Empirical Approach. By Harold D. Lasswell. (International Library of Sociology and Social Reconstruction.) Pp. ix + 309. (London: Kegan Paul and Co., Ltd., 1948.) 21*s*. net.

MAX WEBER was no believer in mystical doctrines of national genius, but he did believe that given societies had their own way of noticing, defining, and solving problems. There was, for example, a British way of approaching physics that differed from the Continental way. This truth is admirably illustrated by these two important new volumes in the "International Library of Sociology". It is not a simple contrast between the German academic temperament and training and the American. Max Weber was, in many ways, *anima naturaliter Americana*. But as a German professor and a German citizen deeply and justly concerned for the present and future of his country, he was bound to deal with different problems than those which rightly concern and interest Prof. Lasswell; and if the publication of these books had no other justification, it would have this, that the two books illustrate this difference of approach and of method.

Max Weber's fame in Britain is mainly due to his "Protestant Ethic", and however much that famous essay may be criticized, it did illustrate an important truth, that there is not, in the nineteenth-century sense of the word, a political or economic 'religion of all sensible men' that has only to be set out to be accepted. The uniqueness of the European economic and scientific achievement was bound up in some form with the 'configuration of institutions'—and of ideas caused by and causing the configuration. It has reasonably been objected that Max Weber simplified his problems, produced too neat contrasts; but he did sow an idea that has had its fruitful crop.

In this collection, naturally, attention has mainly been directed to those parts of Weber's very varied contributions to our knowledge of society that have not been already translated, and it might be said that the reader coming to Max Weber for the first time might do well to read Prof. Talcott Parsons' introduction to "The Theory of Social and Economic Organization" (that is, the recent translation of Part I of "Wirtschaft und Gesellschaft"). But the choice of themes has been judicious and it gives the flavour as well as the weight of Weber's work. For this reason it is probably worth having the essays on the Chinese *literati* and the Indian caste system, though they are not novel or particularly enlightening to-day.

The main themes of these selections are centred around power in its various forms, economic, political and intellectual, and around organisations of power—feudalism, bureaucracy, churches, universities. Contemplating the problems of power, Weber was repelled by two fashionable German doctrines, simple Marxism and the great national superstition of belief in the expert. Marxism repelled him much less than the ignorant and dangerous complacency of the German officers, officials, professors. Professing to be an aristocracy, they were complacent and, in the field of general politics, highly incompetent *dilettanti*. Weber was fascinated by America, to which he went with a far more open mind than did most Europeans, above all than did most Germans. He held the view, not as a paradox but as a saving truth—if only he could get it accepted—that Tammany Hall was a more valuable political institution than the German bureaucracy with its flippant monarchical top-structure and its pedantic, complacent and deeply maladjusted professorial allies and apologists. Few political essays written in a time of crisis read better, a generation later, than "Politics as a Vocation", a sermon in the Munich that knew Kurt Eisner and was about to house Hitler; and the prophecy of the coming of the "charismatic leader" is almost awe-inspiring. Of almost equal interest, though calling for less remarkable powers, is the essay on German universities; and the two taken together explain a great deal about the fate of the Weimar Republic—and the present problems of German rehabilitation.

When we turn to Prof. Lasswell we are conscious of a drier light and a cooler ambition. Prof. Lasswell takes for granted the democratic premise that the object of a democratic society is "the realization of human dignity in a commonwealth of mutual deference". That society will be more easily attained and maintained if we think hard about what we are aiming at and import as much controllable knowledge into our policy-making as is humanly possible. There are many dangers which face American (or any other) democratic society; but Prof. Lasswell is mainly concerned with two. One is the degree to which a society abolishes or encourages "skill blockades", impedes the ability of the individual to contribute to society and to acquire the resources to contribute. All existing societies impede, unnecessarily, such contributions, by financial, racial, dogmatic, political barriers; all are obstacles to the "open society" (to borrow Prof. Popper's useful term). The most interesting example of Prof. Lasswell's analysis of such problems is to be found in his proposals for the reform of American legal education. In no free country do lawyers play so great a part as they do in America. It is not only that constitutional law gives the courts and so the lawyers an importance to which there is no European parallel, but (possibly for reasons that would have interested Max Weber) the lawyer has had his prestige and field of functions greatly extended. So the curriculum of the great law schools is of the utmost importance and the criticism of it made here is very enlightening. Critics of the preliminary training of British Civil Servants or advocates of increasing the number of administrators who are trained scientists might well ponder, in an English context, Prof. Lasswell's questions and answers.

Both these books are so timely that it is perhaps unkind to end on a note of criticism. The translators of Max Weber have excellent principles and nothing could make him easy to read. But too often he has been translated into a language that is almost as near German as it is English or American, and this holds up the reader and may put him off.

D. W. BROGAN

SOLAR AND TERRESTRIAL RELATIONSHIPS

Sunspots In Action

By Dr. Harlan True Stetson. Pp. xiv+252. (New York: Ronald Press Co., 1947.) 3.50 dollars.

THE time is surely ripe for the appearance of an authoritative popular work dealing with the fascinating topic of sun–earth relationships. If Dr. Stetson's book fails to qualify for acceptance in this category, it may well be because he devotes too much space to what is uncertain and speculative, while giving too little attention to those relationships which are clear and unassailable.

The amplitude of the 'daily variations' in the terrestrial magnetic elements has shown a close correspondence with the Zurich sunspot numbers over more than a century. Both variables are capable of precise measurement, and an examination of Fig. 13 in Dr. Stetson's book will show that the correlation between them is of the closest kind. At rare intervals also there occur very violent fluctuations of the magnetic elements, known as 'magnetic storms'. Maunder, of Greenwich, showed, more than forty years ago, that each 'great' magnetic storm coincided in time with the passage of a large sunspot across the sun's central meridian. More precisely, the storm began about thirty hours, on the average, after the central meridian passage of the sunspot. The converse, however, was not true, that the central meridian passage of every large sunspot was followed by a magnetic storm. It remained uncertain whether the corpuscular stream responsible for the storm was emitted continuously from the sunspot region, confined, perhaps, to a narrow radial beam which sometimes missed the earth altogether, or was emitted only intermittently, some of the larger spots being relatively inactive in this respect.

Atmospheric ionization must be attributed in a general way to the action of solar ultra-violet light, with perhaps a small contribution from meteors, and it will therefore reflect in its changes the progression of the spot-cycle. However, with the development of the spectrohelioscope by Hale (1926), chromospheric flares came to be recognized as sudden, short-lived emissions of monochromatic radiation (including enhanced ultra-violet) and having their origin in the vicinity of active sunspot regions. Spectrohelioscope observers, co-operating under the ægis of the International Astronomical Union, rapidly accumulated a large body of facts. These results were discussed by H. W. Newton in an important series of papers, in which he established that each intense (3+) flare was followed by a remarkable train of events. The radiation emitted by the flare is both wave and corpuscular. Simultaneously, with the visual observation of the flare by light of the hydrogen α line, a burst of ultra-violet light reaches the ionosphere, giving rise to: (*a*) the magnetic 'crochet' effect, (*b*) the low-level (*D*-layer) ionization which causes the fade-out for short-wave radio transmissions (Dellinger effect) along sunlit channels of communication. Some twenty-six hours later, with the arrival of the charged corpuscular stream (emitted at the time and place of the flare), the 'sudden commencement' marks the onset of the magnetic storm, with its accompanying radio and visible (auroral) effects. The discussion of the locations on the sun's disk of intense flares preceding magnetic storms makes it clear that the corpuscular stream is confined to a radial beam of semi-vertical angle about 40°.

Thus Maunder's statistical relationship between magnetic storms and the central meridian passages of large sunspots is found to be, in reality, a one-to-one correspondence between storms and intense flares associated with the sunspots near the times of their meridian passages. None of this is made at all clear by Dr. Stetson. Indeed, we find no reference, either in the text or in the bibliography, to the work of Newton, Waldmeier and others on flares, and Maunder is referred to, but in quite a different connexion, as Professor (*sic*) Maunder and in the index as A. S. D. Maunder (which was Mrs. Maunder). The author seems to regard sunspots as the primary phenomenon in all his relationships, whereas most solar physicists would now consider the spots as no more than the visible accompaniments of the much more extensive 'active regions' which are manifest through the occurrence of flares, active prominences, coronal excitations, bursts of radio-noise and in other ways. In Fig. 30 we find an unusual version of Maunder's 'butterfly' diagram, intended to illustrate Spoerer's law of the progression in latitude of sunspots with the eleven-year cycle. In the absence of a description of how the diagram was plotted, the reader will naturally conclude that there are *three* distinct belts of spots, instead of only one, on each side of the solar equator, and that each progresses independently towards lower latitudes as the cycle proceeds.

In the first six chapters the reader will enjoy very entertaining and lucid accounts of such subjects as the origin of solar energy, the measurement of the solar 'constant', the conditions in the ionosphere and the means by which radio-waves are propagated round the globe. There is also an admirable description of ionospheric sounding by the method of 'critical frequencies'. It is clear that Dr. Stetson is much more at home on the radio side.

In later sections the author summarizes much that has been written in an endeavour to relate the sunspot cycle to such matters as the growth of trees, world weather, economic cycles and human health, and he makes a plea for the further study of what he calls 'cosmecology', that is, the relationship of the earth to its cosmic environment. It is in these spheres, where we are no longer dealing with variables capable of accurate measurement, that knowledge becomes vague and a prey to opinion.

M. A. ELLISON

FISHERMAN AND NATURE LOVER

A River Never Sleeps

By Roderick Haig-Brown. Pp. 320. (London and Glasgow: Wm. Collins, Sons and Co., Ltd., 1948.) 12*s*. 6*d*. net.

NO writer has written so vividly of fishing since Lord Grey of Fallodon. Roderick Haig-Brown's book has the rare combination of good prose written by a man who is a master of the subject on which he writes.

The book is divided into twelve chapters, under the twelve months of the year, and the author describes fishing experiences, both in Great Britain and in British Columbia, where he now lives. He is a skilled

fisherman, but he is modest in describing his exploits. He is able to write with so great a vividness that the scene at once is brought before the mind of the reader. Take his description of the death of the Pacific salmon after spawning. This is one of the most strange, even inexplicable, tragedies in the world of Nature. Of the millions of Pacific salmon which enter the rivers to spawn, not one returns to the sea. It is strange, as the author says, that they should all die, not one escape, and strangest of all that the change should be from fullest life to death, with no intermission of growing weakness between. The act of spawning, both in the female and the male, soon brings death, grim and inevitable. The following description (p. 276) of the drama may give an idea of the author's clear and arresting prose: "The will to live continues after spawning. It would be reasonable to expect a resignation to the inevitable, but there is none. A spawned-out fish, almost dead, will turn away from danger in a surge of fear-built strength. I once watched two spawned-out, huge fish, in the shallow water of a long, broken rapid. They showed at first just over the lip of the pool above, dorsal and caudal fins breaking as the current forced them down. They drifted a little way, weakly and awkwardly and then, as though suddenly afraid of death, one threshed its way with furious strength for ten or a dozen yards upstream. The other followed instantly, and for a while they held, side by side again, weaving back and forth until the current caught their sides and swept them down. This happened many times; and each time they were swept down they fought back again, keeping always together but never winning back quite to the place they had left. They swung over at last into an eddy on the far side and seemed to rest there, because I could not see them again. There was a painful sadness in watching, a bleakness in the struggle against death that could gain nothing. . . . It is strange that they should all die, that life should go out with the spawn; for it does go out with the spawn. Age has little to do with it, for even the grilse die."

Yet, as the author points out, not all Atlantic salmon die after spawning. Many of these salmon return to the sea, though a few return again to spawn in the rivers. The restoration of the Atlantic salmon must come within, for there is little feeding in the rivers, yet a 'well-mended kelt' caught in the Scottish rivers in April is sometimes at first glance hard to distinguish from a clean fish. Many of these spawned fish apparently return to the sea in safety, yet very, very few come back to the river to spawn a second time. It is now known that the main feeding area of salmon is in the deep Atlantic. Can it be that the kelts recover their strength, and remain in the deep ocean for the rest of their lives? Otherwise, what happens to the well-mended kelt?

On one occasion when Mr. Haig-Brown was fishing, he watched a bear fishing on the farther side of the river; but the bear was less successful than the human angler (who had caught two salmon) and had no luck at all ("He looked sad and lonely and defeated, the more so because he was so big").

In all the author's writing is sympathy and understanding for the wild creatures. I have likened his writing to that of Lord Grey, yet there is one difference—he writes little of the birds of the rivers he has fished.

His story of his black Labrador reminded me of our faithful collie Dileas. She was as enthusiastic in salmon fishing as I was, and when a salmon jumped far out in a pool she would run with great excitement and stand opposite where the fish had showed, but she did not look from the splash to the rod's top, like the Labrador in this book.

Hear (p. 253) what the author has to say about this remarkable dog:

"When we came to the river he would stand beside me if the water was shallow, or sit on the bank as near to my wading as he could get, ears cocked, legs trembling a little. His eyes would follow the line of every cast, watching the drift of a dry fly or the sweep of a wet fly as closely as I did. If I moved my rod point sharply, he would press forward, his whole body trembling; if a fish jumped free in the river he would look from the splash to the rod top and back again in puzzled surprise to the splash. Whenever I hooked a fish he whined a little and followed every move of the fight until the fish was beaten and I sent him in to retrieve, which he always did faultlessly, bringing the fish to hand without a mark on it to show how he had held anything so awkward and slippery. He retrieved hundreds of fish for me, fish of all weights up to ten or twelve pounds, and I never lost one through him."

One of the charms of this outstanding book is that it must appeal not only to the fisherman, but also to the lover of wild Nature—and indeed to anyone who has an eye for good writing.

SETON GORDON

MICROWAVE ELECTRONIC VALVES

Klystrons and Microwave Triodes

By Asst. Prof. Donald R. Hamilton, Assoc. Prof. Julian K. Knipp and J. B. Horner Kuper. (Massachusetts Institute of Technology, Radiation Laboratory Series, Vol. 7.) Pp. xiv+533. (New York and London: McGraw-Hill Book Co., Inc., 1948.) 45s.

DURING the last year of its existence under the supervision of the National Defense Research Committee, prior to July 1946, the staff of the Radiation Laboratory at the Massachusetts Institute of Technology was chiefly occupied with the writing of twenty-eight large volumes on the scientific principles and techniques of radar: a task which has become known as the "five-foot shelf". The work described in these volumes is, as Prof. Du Bridge says in a foreword, the collective result of work done at many laboratories, Army, Navy, and industrial, both in the United States, in Britain, Canada, and other Dominions. I cannot recall that a task of this magnitude has ever before been undertaken by the staff of a single scientific laboratory. In assessing the achievement, one has to remember that the writing was done at a time when it must have been difficult to show a proper historical sense in relation to the share of other countries and laboratories; the personal and even the national share in any one discovery had often been lost in the tremendous urge to make of radar a decisive weapon of war. Many volumes of the series are still to appear; but all were written before the spate of post-war scientific papers had set in. Some effects of this no doubt deliberate editorial policy can be seen in the volume under review: the index contains very few references to individuals; such references are confined almost entirely to textual footnotes. In a book

which devotes many of its pages to the klystron, one is surprised not to find the name Varian in the index. As is usual, scientific progress outstrips the speed of publishing, and reference to the important work at Oxford on the travelling-wave tube is confined to the preface.

Volume 7 deals with the basic principles underlying the operation of klystrons and planar-grid valves (such as the lighthouse and disk-seal types) as oscillators and amplifiers, with special emphasis on fundamental principles rather than descriptive or constructional details. The first four chapters discuss the fundamentals of valve types and function, electronic and circuit phenomena at high-frequencies. Chapters 5–8 are concerned with planar space-charge valves as amplifiers and oscillators and the pulse operation of microwave triodes.

More than half the book (Chapters 9–18) deals with klystrons, and the treatment is comprehensive. There are chapters on velocity modulation and klystron bunching, amplifier klystrons; frequency multiplier and reflex klystron oscillators, load effects, and hysteresis; noise in reflex klystrons; modulation, and practical reflex klystrons.

Chapter 15 on load effects in reflex klystrons is good, and of quite general usefulness apart from its context; the long-line phenomena are discussed in quite a clear way. The British reader, perhaps inevitably, takes exception to occasional Americanisms; this text is singularly free from such defects or jargon. The use of the term 'electronic equivalent' in the sentence "probably the best known type of the external cavity is the 707B or its electronic equivalent, the 2K28" on page 495 is certainly, however, open to objection.

Those who have some acquaintance with the subject-matter of this volume will already be aware that it cannot be presented without a good deal of mathematical background. The volume is well suited to those wishing to make use of klystrons and microwave triodes in a particular field of research. It is not suited, as a whole, to the undergraduate, unless he is fortunate in having an expert to guide him. There are, however, chapters of special value in this connexion; readers whose interest is of a general character would do well to study the relevant portions of the introductory volume to the series, edited by L. N. Ridenour. J. T. RANDALL

INTERNAL SECRETION

Textbook of Endocrinology

By Prof. Hans Selye. Pp. xxxii+914. (Montreal: University of Montreal, 1947.) 10.25 dollars.

PROF. SELYE's "Textbook of Endocrinology" is probably the most complete account of the subject which has yet appeared, at any rate within the compass of a single volume. It is, however, only a miniature of the much larger "Encyclopædia of Endocrinology" which the author is bringing out in many volumes, six of which have so far been published, but which, it is hoped, will ultimately give a critical survey and a complete guide to the entire endocrinological literature. The present volume begins with an interesting preface by Prof. Houssay, of Buenos Aires, who points out how far we are from the theories which prevailed between 1880 and 1900 and which attributed to the internal secretions the role of neutralizing and destroying the toxic substances arising in intermediate metabolism. Long before that time, however, Berthold definitely promulgated the idea that an organ may exert its influence upon the bodily characters or upon other organs by means of chemical substances secreted internally into the circulating blood. This was in 1849, when he published his experiments upon testicular transplantation in fowls. His work was for many years lost sight of; but his results have been completely confirmed. In the meantime, Claude Bernard employed the term 'internal secretion' to describe the glycogenic function of the liver, because this gland stores up carbohydrate as glycogen and secretes it into the blood as sugar. Brown-Séquard's claims, made in 1889, to have rejuvenated himself as a consequence of injections of testicular extract attracted a great deal of attention, and although they did not stand the test of a later examination and repetition, nevertheless are usually regarded as marking the beginning of the modern science of endocrinology. The term 'internal secretion' is now usually restricted to substances which, after being carried in the blood-stream, promote the secretion of particular glands or the growth of particular tissues on which they have a specific action. Such chemical excitants were named 'hormones' by Starling in 1905. Prof. Selye does well to remind us of the beginnings of a science which in recent years has developed into such a large and important branch of physiology.

In the succeeding chapter, the author describes the chemistry and pharmacology of the steroids. This is a group which contains four sub-divisions of substances of similar chemical constitution and hormonal action, namely, the œstrogens, the androgens, the progesterone-like bodies and the compounds with a 'cortin-like' action. It is interesting to note that any one of these substances may produce not only its own characteristic effects but also some of the effects of those of the other three groups. The author next deals in alphabetical order with all the organs of internal secretion, and the account of these is followed by a chapter on the hormones or hormone-like substances produced by simple endo-exocrine and non-glandular organs, and a final chapter on functional correlations. The pathology of the organs is very fully described, and this is a feature of the book. There are numbers of illustrations and many of these show the effects of endocrine diseases.

In a book of this size, it was inevitable that there should be mistakes, as the author himself remarks; but it is unfortunate for science when an important text-book contains misleading statements about the reproductive processes of common domestic animals, and such as any practical breeder knows to be absurd; for example, the statement that the so-called pre-œstrous bleeding in the dog occurs at the mid-interval between two œstrous periods. Moreover, monœstrous mammals are those with one œstrus in the sexual season, not those with one cycle per annum, as the book states; and again, the diœstrum is not a phase of complete sexual rest but an abbreviated pseudo-pregnancy. There are other similar mistakes; but they must not be regarded as detracting seriously from the value of the work as a whole. In my opinion the book would benefit by giving the references to the more important papers that are quoted, for this is only occasionally done.

F. H. A. MARSHALL

A TECHNIQUE FOR MECHANICAL VIBRATION PROBLEMS

Mechanical Admittances and their Applications to Oscillation Problems

By Prof. W. J. Duncan. (Ministry of Supply: Aeronautical Research Council, Reports and Memoranda, No. 2000.) Pp. 128. (London: H.M. Stationery Office, 1947.) 22*s*. 6*d*. net.

IN the days when electrical engineering was emerging from physics and when alternating current circuit theory was in its infancy, progress was greatly helped by the fortunate circumstance that the equations to which the new theory led were formally similar to those already encountered in mechanics. Thus Maxwell, in his treatise, devotes a chapter to the dynamical principles and equations of Lagrange and Hamilton, and is at pains to stress the fact that the circuit equations fall within their scope. As it grew, electric circuit theory elaborated concepts, developed techniques, and invented a nomenclature, appropriate to the problems encountered and to their growing complexity. More recently, problems in mechanical vibrations, of increasing complexity, have presented themselves, notably in aeroplane design, and circuit theory has been able to repay with interest the debt it has for so long owed.

The word 'admittance' in the title of this monograph is borrowed from circuit theory, where it signifies, for any branch, relative to a pair of terminals, the ratio of current in the branch to E.M.F. across the terminals. The most obvious analogue of electric current is mechanical *velocity*, but since the interest in mechanical problems is more often focused on *displacement*, the liberty has been taken of altering the significance and of defining 'mechanical admittance' as a ratio of displacement to force—with 'displacement' and 'force' used as in the language of generalized co-ordinates. More immediately descriptive terms would have been 'dynamic flexibility', or a 'dynamic influence coefficient'—expressing the harmonically varying response to a harmonically varying unit stimulus.

The power of the 'admittance' method lies in the ability it confers of expressing rapidly the displacements at chosen key points of a system in terms of internal and external forces acting on the system or upon a sub-system. Eliminating internal forces from the set of equations so formulated leads to either (i) the frequency equations in the absence of external forces, or (ii) equations for the chosen (generalized) co-ordinates in terms of the external forces. As the author says of admittances, "their use greatly facilitates the splitting of problems on mechanical vibrations into manageable portions", so that "the range of tractable problems is greatly extended".

The monograph contains an elementary exposition of the fundamental ideas, with examples of their application to a number of systems. The purpose is didactic, and the examples are 'academic', but the advantages of the method are clear to see, and students and designers should derive much profit therefrom. There are conceivably other topics upon which similar monographs might be included in the Reports and Memoranda Series issued by the Aeronautical Research Council, and Prof. Duncan may be congratulated upon creating an excellent precedent.

The electro-mechanical analogy is, however, not perfect, and the technique of mechanical admittances has not yet acquired all the facility of electric circuit theory. The idea of mechanical 'circuits' needs elaboration, and the analogues of Kirchhoff's laws would seem desirable, although the greater complexity of mechanical couplings and interconnexions does present some difficulties.

W. G. BICKLEY

COLLEGE PHYSICS

College Physics

By Prof. John A. Eldridge. Third edition. Pp. x + 720. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1947.) 27*s*. net.

College Technical Physics

By Robert L. Weber, Marsh W. White and Kenneth V. Manning. Pp. x + 761. (New York and London: McGraw-Hill Book Co., Inc., 1947.) 22*s*. 6*d*. 4.50 dollars.

THESE two text-books, designed for use in the first-year course of American colleges, are suitable for classes in Britain of intermediate degree examination standard, particularly where a combined course of instruction is given for students from various faculties. The subject-matter is similar in both, covering mechanics, heat, sound, electricity and magnetism, and optics. Calculus is not used, and only an elementary knowledge of algebra and trigonometry is required.

"College Physics", which is now in its third edition, first appeared in 1937. In the new edition a large part of the text has been rewritten, a slight change made in the order of presentation, and a greater number of worked-out examples given, though the problems at the ends of the chapters have not greatly altered. The author has tried to arouse an interest in physics and to make the student think for himself. In this he has succeeded admirably, but it is a pity that occasionally he has allowed his enthusiasm to run away with him, for some of his language is much too colloquial and his historical sketches very often ridiculous. The diagrams and explanations are very clear, and fundamentals are carefully stressed. The British 'gravitational' system (in which the unit of mass is the 'slug'), and the C G S. system of units are used.

"College Technical Physics" is a new book, although some of the material has been adapted from an earlier book of the authors entitled "Practical Physics". It is on conventional lines, with one unique feature—the chapter headpieces. These are portrait drawings by C. S. Hauschka—one for every chapter—of the fifty Nobel prize winners in physics, arranged in chronological order, from Röntgen in 1901 to Bridgman in 1946. Every portrait is accompanied by a brief biographical note. The portraits bear no relation to the chapters to which they are attached, nor is any reference made to the drawings in the text. Indeed, several of these eminent physicists, for example, Sir J. J. Thomson, who it is expected would be mentioned even in an elementary text-book, get no mention at all in the text. The book is very well produced and contains some excellent illustrations, both line drawings and half-tones. In particular, the chapter on colour, with its unusual but excellent coloured illustrations, must receive special commendation.

S. WEINTROUB

The Electron Microscope

By Dr. V. E. Cosslett. (Sigma Introduction to Science, 8.) Pp. viii+128+12 plates. (London: Sigma Books, Ltd., 1947.) 7*s*. 6*d*. net.

THIS little book can be confidently recommended to those for whom it is written—the biologist and others seeking information about a new tool and the layman interested in recent scientific advances. It contains a non-mathematical account of the principles underlying the construction of an electron microscope. Starting with a description of the properties of an optical lens and the formation of an image by rays of light, the book proceeds to develop the analogy with electron lenses of both magnetic and electrostatic type. The account is at all times clear and simple; and the large number of illustrations and plates make the book easy to read and to understand.

The book concludes with two chapters on the present uses and future possibilities of the electron microscope. The first of these serves to emphasize the rapidity with which this new method of investigating the fine structure of matter has been exploited both in fundamental and industrial research. The second suggests that further developments are still possible and are being actively pursued. G. D. P.

Les mesures physiques

Par Albert Pérard. (Que sais-je ?, No. 244.) Pp. 136. (Paris: Presses universitaires de France, 1947.) n.p.

IN this paper-covered pocket edition, one of the well-known 'Que sais-je?' series, the director of the Bureau International des Poids et Mesures gives an authoritative, concise, and logical account of the important part played by measurement in science. The first chapter deals with the general principles and methods of measurement, and errors of observation. The following chapters discuss, in terms of the fundamental standards, the measurement of length, time and mass, and electrical measurements; and, since a knowledge of the temperature is essential for the exact specification of the fundamental quantities, a further chapter describes the methods used to measure temperature. The final chapter indicates briefly the principles of measurement of several other physical quantities, and an appendix tabulates equivalents of the principal units.

It is no easy task to deal adequately with the subject of measurement in such a small volume, and the author is to be congratulated on the skilful way in which he has chosen and handled his material. Unnecessary detail is avoided, and only a few absolutely essential references are given, so that even those possessing only a slight knowledge of physics will have no difficulty, when reading this book, in appreciating the basic principles and methods of physical measurement. S. WEINTROUB

Simple Experiments with Insects

By Dr. H. Kalmus. Pp. xii+132. (London: William Heinemann, Ltd., 1948.) 7*s*. 6*d*.

THE surest way to arouse interest in a scientific subject is to make it interesting; to perform actual experiments is one way of doing this. In this little book Dr. Kalmus describes more than a hundred experiments in insect behaviour and physiology for the benefit of amateurs or of school children and their teachers. The experiments range from such simple things as putting a bee in a bottle and showing that it produces water, or catching a fly in the hand, to quite difficult experiments such as the comparative rearing of *Drosophila* on synthetic media or studying the optomotor reactions of the mosquito. Even with the help of the short explanations which accompany the descriptions, it is unlikely that the amateur will grasp the significance of all the experiments; but many of them are well calculated to excite his interest, and the book should prove a useful complement to the observations of insects in the field. It is likely to be useful, too, for university teachers of zoology. A few errors may be noted: the yolk is not formed by the accessory glands (p. xii); hæmoglobin is not broken down beyond hæmatin in the mosquito (p.15); on p. 20 'gills' are called 'tracheæ'; on p. 83 the book louse is called *Anthrenus*.

V. B. WIGGLESWORTH

Guide to the Study of the Anatomy of the Shark, *Necturus*, and the Cat

By Prof. Samuel Eddy, Prof. Clarence P. Oliver and Asst. Prof. John P. Turner. Second edition. Pp. vii+115. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1947.) 12*s*. net.

THIS admirable little book, which was designed for students of the University of Minnesota, is accurately described in its title. It gives the salient features of the anatomy of the three animals with which it deals in the form of directions for their dissection. It has the virtue that it is concise, but one feels that students might have been helped by more detailed statements of dissection procedures. Unlike many British text-books, there is some treatment of the muscles; it is perhaps to be regretted that they were not a little more fully treated in the spiny dog-fish. The illustrations are rather few but they are clear and pleasant to look at; the last point is important, as increasing the likelihood that they will be studied. It would have been an advantage to have given some very simple sketches showing dissection methods. The book is clearly printed on thick paper, the pages held together between card covers by metal rings which enable the book to lie flat on a bench. P. D. F. MURRAY

The Psychology of Industry

By Prof. James Drever. Second edition, revised. Pp. x+151. (London: Methuen and Co., Ltd., 1947.) 7*s*. 6*d*. net.

THE appearance of a second edition of this work some twenty-six years after the original is a tribute to the work of a pioneer. During the First World War experimental psychologists made one or two attempts to show how science could appreciably add to the productivity of industry. By the time of the Second World War the more up-to-date industrialists had realized that the nineteenth-century stress on material and monetary factors in industry had been greatly overdone and that efficiency could only be approached when as much attention was paid to the human factor. Prof. Drever's book is a record of the work done by himself and other investigators between the two wars. While it pays little attention to developments in industrial relations since that time, it is still a worthy guide for all who are seeking to provide optimum satisfaction to workers in industry and, concurrently, to raise the overall level of industry's productive capacity.

T. H. HAWKINS

THE ROLE OF CHEMISTRY IN COMBATING TROPICAL DISEASES*

By Sir IAN HEILBRON, F.R.S.

TO a great Colonial Power such as Britain, the control of the insect-borne diseases, malaria and trypanosomiasis, the vectors of which are respectively the Anopheles mosquito and the tsetse fly, is of paramount importance. Malaria, which claims anything from 300 to 800 million victims a year, with an annual death roll of 3 to 4 million, is the most prevalent of all human infectious diseases and the worst scourge with which we have to contend throughout all our tropical and sub-tropical Colonies. It is not only responsible directly for enormous damage to health but it so lowers vitality by its destruction of blood cells that other infections are enabled to create perhaps even greater destruction than the malaria itself.

The direct cause of all this sickness is a protozoon belonging to the genus *Plasmodium*. Of the three species, *P. vivax*, *P. falciparum* and *P. malariæ*, concerned, each produces distinctive symptoms and requires different treatment. They are injected into the blood of humans by the females of Anopheline mosquitoes during their act of sucking blood upon which they live. Of the hundred and forty or so different kinds of Anopheline mosquitoes, fortunately only about fifteen of these are important vectors of malaria. Thus in Africa the main carriers are *Anopheles gambiæ* and *A. funestus*; in America they are *A. quadrimaculatus*, *A. punctipennis* and *A. crucians*; and in India, *A. stephensi*, *A. culicifacies* and *A. rossi*, and so on.

Trypanosomiasis, or sleeping sickness, unlike malaria, is confined to Africa. Human sleeping sickness is caused by two species of trypanosomes, *T. gambiense* and *T. rhodesiense*. The latter produces a virulent type of the disease particularly difficult to control by drugs. The trypanosomes responsible for trypanosomiasis among domestic animals differ from those affecting humans. Of veterinary importance, mention may be made of *T. congolense* and *T. vivax*, of which the former is much the more virulent among cattle and presents the most serious veterinary problem. *T. brucei* is generally fatal to horses, while *T. simiæ* is a strain particularly dangerous to pigs. The organism responsible for transmission of the disease is the tsetse fly. Among the many species of tsetse, *Glossina morsitans* and *G. pallidipes* range over wide areas of bush, scrub and forest country and are found in all altitudes up to about 5,000 ft. A fly of a different habitat is *G. palpalis*, which generally lives in the proximity of water.

For Africa, especially equatorial Africa, trypanosomiasis is just as grave a problem as malaria, for where tsetse rules uncontrolled, domestic animals cannot exist, and thus vast tracts of valuable grazing land which fall within the fly-belt are left unstocked and uninhabited. As a result, the number of cattle in Africa is tragically small, but even so over-grazing occurs in many areas. In turn, the human population suffers from a deficiency of animal protein, the soil loses fertility due to lack of manure and generally conditions are created wherein disease, poverty and misery alone thrive.

* From a Friday Evening Discourse at the Royal Institution on May 14.

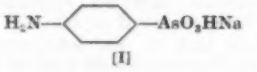
Malaria and trypanosomiasis constitute, without doubt, the biggest hindrance to the economic, social and political development of those territories afflicted by them. Until control of these diseases is effected, we cannot reasonably expect native communities to be sufficiently vigorous, either physically or mentally, to be entrusted with the many responsibilities which the rapid imposition of our social and political systems must throw upon them.

There are two distinct approaches to the problem. We can attempt either to destroy the parasites in man and animals, or we can concentrate our attention on the eradication of the vectors themselves. Both lines of investigation have been actively explored with considerable success for many years.

The search for synthetic drugs for combating both malaria and sleeping sickness has been pursued with increasing tempo ever since Paul Ehrlich, the brilliant founder of modern chemotherapy, established in the first years of the present century the principle that infectious diseases could be cured by employing specific chemical agents to bring about the selective destruction of the invading parasites.

Chemotherapy of Human and Animal Trypanosomiasis and of Malaria

With the experimental production of trypanosomiasis in mice and rats by Laveran and Mesnil in 1902 and the demonstration by Thomas in Liverpool in 1905 of the trypanocidal activity of atoxyl (I), Ehrlich decided to focus his attention on compounds of arsenic, rather than pursue his studies on purely organic compounds where some promising results had already been attained in mouse trypanosomiasis with a dyestuff, trypan red. As is well known, the culminating point of this series of investigations was the discovery of 'Salvarsan' (II) by Ehrlich and Hata in 1910 as a cure, not for sleeping sickness, but for the spirochætal infection syphilis. For human sleeping sickness the most successful and widely used arsenoorganic compound is still 'Tryparsamide' (III), first described by Jacobs and Heidelberger in the United States in 1919. Its virtue lies in the fact that it is the only drug with any action in the deadly late stage of sleeping sickness when trypanosomes have penetrated into the central nervous system.



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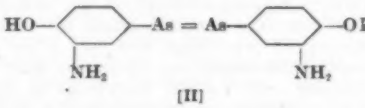

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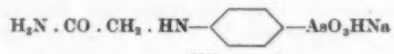
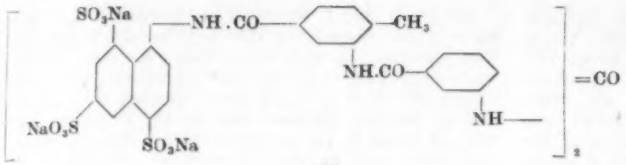


[III]

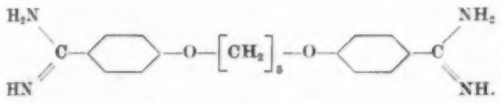
Turning now to purely organic compounds, the search for trypanocides along the lines of Ehrlich's azo dye, trypan red, has led to the discovery in Germany of Bayer 205, also known as 'Germanin', 'Suramin', 'Antrypol', etc. This substance represents the most successful chemotherapeutic agent so far discovered for human sleeping sickness in its early stages. A single dose confers a trypanocidal power on the blood for a long period, while resistance of trypanosomes to it is acquired more slowly than with



[IV]

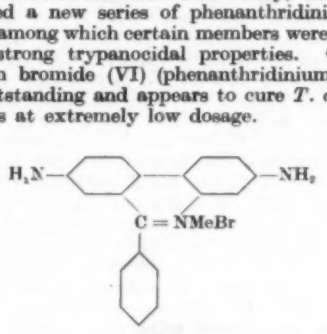
arsenical preparations. Furthermore, it is of value against *T. rhodesiense*, where arsenicals are ineffective. On the other hand, it is of no use in the later stages of the disease, and this seems to suggest that it cannot penetrate the blood-brain barrier.

Another highly important group of chemotherapeutic agents for human sleeping sickness are the diamidines, which have been developed in Great Britain following upon an investigation of Lourie and Warrington Yorke in Liverpool. Among the members of this series, pentamidine (V) is used on a large scale by Belgian, British and French medical services. It is an extremely powerful trypanocide for treatment of the disease in the lymphatico-blood stage, but like 'Suramin' is ineffective in cases of severe nervous involvement.



[V]

Until recently, the search for synthetic drugs effective against the dreaded *T. congolense* infections in cattle has been unsuccessful and only tartar emetic and certain other antimonials have been found of any value. In 1931, Morgan and Walls, working in the Chemical Research Laboratory, Teddington, discovered a new series of phenanthridinium compounds, among which certain members were found to possess strong trypanocidal properties. Of these, dimidium bromide (VI) (phenanthridinium 1553) is quite outstanding and appears to cure *T. congolense* infections at extremely low dosage.

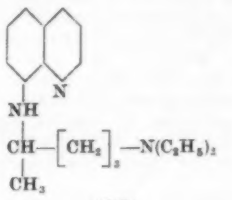


[VI]

The use of the drug is, however, not unattended by danger, as it is toxic and produces in cattle photosensitization if used in large amounts.

As a result of the world-wide distribution of malaria, the subject of specific therapy has commanded a great deal of attention. This was particularly the case during the Second World War, when both British and American troops were operating in some of the worst malarious spots in the world. The position was aggravated by the fact that quinine, the ordinary prophylactic and curative drug, became unavailable in consequence of the Japanese invasion of Java, which cut off our supplies of cinchona bark.

The possibility of studying the effect of drugs upon the malaria parasites was opened up when Roehl, one of Ehrlich's pupils, developed a method in 1926 of transmitting a related infection, *Plasmodium relictum*, to canaries. Following upon this discovery, chemical research work was actively pursued and rapidly resulted in the discovery in Germany of 'Plasmoquin' (VII) ('Pamaquin'), followed shortly afterwards by that of 'Atebrin' ('Mepacrine') (VIII) in 1930 This latter compound has proved to be a more



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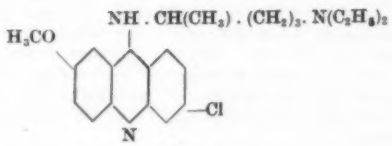
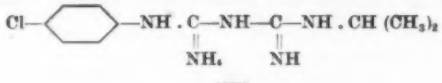


[VIII]

effective suppressive than quinine, and its manufacture in Britain was begun during the War. The discovery by Curd, Davey and Rose of the important antimalarial 'Paludrine' (IX) in 1944 as a result of brilliantly planned war-time research in the laboratories of Imperial Chemical Industries, Ltd., at Blackley, marks a still further striking advance in chemotherapy. As is seen from the formula, 'Paludrine' is an entirely novel drug quite unrelated structurally to either 'Pamaquin' or 'Mepacrine'. Unlike the latter, it is colourless and hence produces no discoloration of the skin. At the same time, it is less toxic, and both for prophylactic and curative purposes is vastly superior.



[IX]

Attacking the Insect Vector

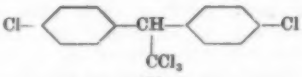
No one can question the great importance of the use of drugs for the treatment of either malaria or trypanosomiasis; but it is well recognized that in our Colonial territories with their many tribal communities, or in India with its teeming population, there is as yet no practical possibility of stamping out insect-borne diseases by such methods. The only alternative is to secure control by exterminating the vectors.

The idea of eradicating malaria and sleeping sickness in this way is, of course, not novel. The attack upon the mosquito by the drainage of swamps, the spreading of oil on water and the use of Paris Green for dusting to kill larvæ, and the spraying of houses

with pyrethrum extract in kerosene are all methods which have been practised for a great many years. In 1930, a serious epidemic of malaria broke out in Brazil due to the introduction of *Anopheles gambiæ* into that country, probably by sea, from Africa. An area of 12,000 square miles was affected, but through the joint co-operation of the Brazilian Government and the Rockefeller Foundation complete eradication of the species was attained. Similarly in 1942, *A. gambiæ* spread from Central Africa into Egypt, causing a serious epidemic of malaria. The Rockefeller Foundation experts were again called upon to assist the Egyptian Government. Paris Green was employed as the principal insecticide and applied to all potential breeding places. House-to-house spraying with pyrethrum was also employed throughout the whole of the infested area. By 1945 the area was free from infestation. I mention these two campaigns as they serve to demonstrate what can be achieved by careful planning. The cost both in money and labour was high, but the extermination of the disease-carrying mosquitoes was achieved.

With the discovery of the newer and almost unbelievably potent insect-killing chemicals D.D.T. (dichlorodiphenyl-trichloroethane) (X) and benzene hexachloride ('Gammexane') the whole scheme of things has, in my opinion, become transformed. We have in these substances enormously powerful weapons for the waging of successful war against the mosquito, the tsetse and other vectors of human diseases.

So much has already been written about these two insecticides that it is unnecessary for me to do more than recall the fact that, like pyrethrum, they are contact poisons; but unlike the natural material which rapidly oxidizes in air and so loses its potency, D.D.T. is a comparatively stable substance remarkably resistant to oxidation, and thus capable of exerting insecticidal effects upon sprayed areas for prolonged periods. In addition to the above substances, many other powerful synthetic insecticides and miticides of promise have been produced in the United States. Of these, mention may be made of 'Chlordane', a chlorinated indane derivative, and 'Thiophos 3422' ('Parathion') (XI), which is said to be more effective against a wider range of insects and mites than any chemical now in practical use, and a series of alkyl polyphosphates originally prepared in Germany as a substitute for nicotine under the name 'Bladon'.



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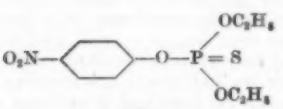


[XI]

Many experiments on insect control are being carried out in British Colonies, either by the respective Colonial administrations themselves or in conjunction with the Colonial Insecticide Committee set up by the Secretary of State for the Colonies, Mr. Creech Jones, at the beginning of 1947.

Although D.D.T. was used so extensively and with such success during the War both by the Americans and ourselves, we were by no means satisfied that we were employing it to the best advantage. Thus we commonly used a 5 per cent solution in kerosene simply because kerosene was readily available, and we had failed in our attempts at that time to obtain good emulsions or wettable powder. Similarly, we lacked precise information as to the best methods of spraying and made do with what equipment was available. Thus in the case of aircraft sprays, use was made of equipment originally designed for gas warfare.

Even to-day, comparatively little is known of the performance in tropical countries of fixed-wing aircraft as a means of disseminating insecticides, and nothing of the efficiency of the helicopter for that purpose. Experiments on these lines are now about to be conducted in Uganda and Tanganyika using a variety of insecticide formulations, including smokes, oil solutions, emulsions, water suspensions and aerosol fogs. Much research has also to be carried out on such unsolved problems as the causes and prevention of absorption of insecticides by mud and thatch, the absorption and decomposition of insecticides by green leaves, the use of surface-active agents to help the spray wet the leaves and insects, and the relationship between crystal size and toxicity. These and many other questions that have arisen during field trials necessitate studies of a fundamental nature which can only be satisfactorily undertaken by a team of scientific workers, including chemists, physicists, biologists, chemical engineers and other specialists. The Colonial Insecticide Committee, with the co-operation of the Ministry of Supply, is therefore establishing a research unit at Porton to undertake the necessary investigations.

In the meantime, large-scale experiments are in hand. The first of these was initiated in 1945 in British Guiana, where more than 70 per cent of the population, some 250,000 people, live under conditions of severe endemic malaria. The initial work was directed by Mr. C. B. Symes, now officer in charge of research for the Colonial Insecticide Committee, and was later taken over and expanded by the Government malariologist. Before spraying was commenced, 700–800 mosquitoes would be found in one small bedroom. These included not only the malaria carrier, *Anopheles darlingi*, but also *Culex fatigans*, which are carriers of filariasis, and *Aedes ægypti*, which are potential carriers of yellow fever. Spraying was carried out with 5 per cent D.D.T. at a dosage of 100 mgm. per sq. ft. to the inner surfaces of dwellings. After as long as ten months and using only a single spraying, *A. darlingi* mosquito captures were down to less than 2 per cent of the numbers in untreated huts. To date, approximately 84 per cent of the population are enjoying total protection from malaria. In one village where more than 60 per cent of school children showed chronic infection by malaria in 1945, only 18 per cent were infected in 1946. In 1938 the spleen index in school children was 51·2, whereas in 1947 it had fallen to 3·7.

Another highly successful experiment is being carried out in Cyprus. In the past, various efforts have been made to control the disease by treatment of water areas with oil and with Paris Green, but without success. In 1946 a large trial was conducted in the Karpass Peninsula over a total area of some

7,000 square miles. The attack, directed by Mr. M. Aziz, the chief health inspector, was concentrated upon larvæ in water courses, pools, wells, etc. Spraying was carried out in most places every fourteen days from April to the end of October, when *Anopheles*, both adult and larvæ, were completely eliminated from the area. The work was being extended in 1947 and it was confidently anticipated that the complete eradication of mosquitoes from Cyprus could be expected within two or three years.

A malaria eradication experiment is now being prepared to be conducted in the island of Mauritius, commencing in the autumn. Malaria was introduced into the island about 1862 and is now endemic. The disease is the principal cause of death in the Colony, the population of which is about 420,000. Most of the infection is due to *A. funestus*, supplemented by *A. gambiæ*. Apart from the highest part of the island, which excludes some five thousand houses from a total of eighty-three thousand dwellings, all houses and cattle and goat sheds in the remainder of the island are to be treated by the application of residual insecticidal formulations three times a year over a period of two years. If necessary, the extension of spraying to breeding grounds will be put in hand.

Large trials are also in progress in East Africa. These are being conducted by the Colonial Insecticides Research Unit in Uganda, and cover both work on mosquitoes and tsetse flies. An interesting field experiment was carried out in a rural area north of Entebbe in Uganda, in which some two thousand houses of the mud wall and thatched roof type were divided into six areas and treated with six different formulations of D.D.T. and benzene hexachloride. All treatments caused striking reductions in populations of mosquitoes in houses. Four sprayings prevented the usual seasonal increase of malaria, and two of these apparently resulted in a reduction of malaria by about 50 per cent. These results were obtained over two wet seasons.

An important factor in field trials is the reaction of the people to the experiments, especially as they involve removal of foodstuffs, clothes, etc., from the rooms to be sprayed. Actually Mr. Symes relates that the reception everywhere was so good that at times it became embarrassing. For the first time in their lives these people experienced an undisturbed night's sleep, free from the evil presence of hundreds of biting mosquitoes as well as bed bugs, 'chigger' fleas which burrow under the skin and nails of feet and hands and cause septic sores and many other pests.

Tsetse Flies

Interesting and promising results have also been obtained in field experiments with insecticides conducted by the Uganda research team on the tsetse-infested islands and shores of Lake Victoria (in Central Africa), by the South Africans in South Africa, and by the East African Tsetse Research Department in Tanganyika. Tsetse flies, both males and females, live by sucking the blood of animals, including domestic animals and man, where these are available, and they breed and live in bush (or jungle) of various kinds. Their young spend all their development period—some eight weeks upwards—in the soil, so that they are difficult to get at. It is the adult fly, therefore, while it is resting on leaves, tree-trunks and stones in the bush, or actually in flight looking for food, or while feeding on an animal, that is vulnerable to attack with insecticides.

Two obvious methods are the spraying of the bush and the spraying of cattle with contact insecticides. The first method has been tried on a number of small islands of 100 acres or so and on stretches of dense shore bush on Lake Victoria. Solutions and emulsions of D.D.T. and benzene hexachloride were applied with small knapsack sprayers to bush in places where the flies concentrated or patrolled. In order to do this and to do the necessary preliminary survey of fly densities, paths were cut through the bush. It was, of course, possible to spray only a small proportion of the total bush in this manner. In spite of this, the reduction in the fly population in the last few experiments was about 98 per cent. In one trial no flies could be found for nearly three months after the last of four sprayings. While this work was going on, it was discovered that the oil solutions that were being used appeared to lose their effect on flies after about a week because a very large proportion, sometimes as much as 80 per cent, was absorbed by the leaves and stems of the trees and bush. One of the urgent inquiries, therefore, is now to find formulations of D.D.T. and benzene hexachloride that will not be absorbed by plants and trees, and it seems that certain types of emulsions or wettable powders may suit in this way.

Since such a large proportion of the total flies were killed by treatment of so small a proportion of the bush, it is thought that by increasing the area sprayed, even the last 2 per cent of flies will have difficulty in escaping. It is proposed, therefore, to do this, and since no known type of ordinary spraying equipment is suitable for use in these large areas of dense bush, the spray is to be applied from aircraft. Extensive trials of this method are now planned to begin in a few months.

Trials of insecticidal smokes and fogs drifted through the bush have also been conducted with very promising results. The smokes have been produced from grenades and canisters, filled with burning mixtures and the insecticides mixed together. The fog was discharged from a special machine.

The South Africans have gone further than this with trials of insecticidal smokes for the control of tsetse flies (*G. pallidipes*). For the past two years or so they have used aircraft for this work and have treated about 170 square miles several times with smoke made from a 20 per cent solution of D.D.T. in toluene and fuel oil. The aircraft fly just above the tree-tops and the smoke is produced from their exhaust pipes, which are connected to the internal spray-tanks for this purpose. Kills of tsetse have been good over the areas as a whole (up to more than 99 per cent), but small numbers of flies have been left unharmed in dense evergreen thickets to which the smoke has not penetrated. These small pockets are now being dealt with by means of smoke canisters. South Africa has expended more than £300,000 and much effort on this work, and has had the full co-operation of its Air Force. The British effort has been much less costly so far, but it is likely to build up to a similar order of magnitude in the near future —in fact it must, if we are to deal with this problem in anything like an adequate fashion.

There is a second method of application, namely, the spraying of cattle with insecticide so that flies settling on them to feed come into contact with the insecticide crystals and so are affected. This has been

tried by the Tsetse Research Department of Tanganyika. After preliminary work, they sprayed 350 cattle once a week for thirteen weeks and then twice a week for another eight weeks with 9 per cent D.D.T. solution in monkeynut oil plus resin. The cattle after each spraying were herded in small groups of five or six over an area of about five square miles of bush infested with the tsetse (*G. pallidipes*). At the end of this period the tsetse had been reduced by about 80 per cent. During this work it was found that the solution when applied to cattle lost its toxicity in a few days, though the same solution applied to a dried ox skin was toxic for months. Subsequent investigation has shown that this is due essentially to absorption of the solution into and through the living skin. This line of investigation will continue.

Effective application of insecticides is not quite the simple problem that it may seem. Chemical, biological, physical and engineering studies are all deeply involved and intermixed. It is only in so far as we are able to cope with these interrelated problems that we may expect to make progress. Our effort so far, however promising—and the results are very heartening—is a very meagre one. We in the British Commonwealth of Nations are faced with all the major insect-borne diseases and pests of animals and crops in larger measure than any other group of peoples. In the past there has seemed to be no way of dealing with these problems in any reasonable period. But with the new insecticides, supplementing the best of the old, we have weapons of which we have not hitherto dreamed. The future holds a challenge which we dare not refuse.

THE HEALTH OF THE SCHOOL CHILD

By Dr. ROBERT SUTHERLAND
Medical Adviser and Secretary, Central Council for Health Education

NOT the least of British war-time triumphs was the way the health of the children was maintained and even improved. Except in 1940–41 the death-rates in the war years were equal to or less than pre-war rates. There was an improvement in the height and weight of both sexes, the number of children with really bad nutrition was roughly halved, and the amount of anæmia was reduced.

These striking improvements took place although many children suffered the stresses of air raids and the disruption of evacuation, and although the staffs of school medical and school dental services were reduced because many of their members were serving in the armed forces.

There is no doubt, therefore, that these encouraging results were largely due to a raising of the standard of living of the poorer half of the population, to our very well-designed system of rationing, with its priorities for mothers and children, and to the tenfold increase in school dinners and the 30 per cent increase in the taking of school milk.

Part of the fall in the death-rates was due to a reduction in deaths from respiratory infections, notably pneumonia, and from diphtheria. The development of chemotherapy probably had much to do with the fall in pneumonia deaths, and the diphtheria immunization campaign introduced in 1942 was certainly largely responsible for the striking reduction in the diphtheria deaths.

The report of the Chief Medical Officer of the Ministry of Education for the years 1939–45* very properly stresses the ground that has been gained in difficult circumstances. But equally properly Sir Wilson Jameson notes some challenging facts that still confront us.

The nutrition of one out of every six (or at best one out of every nine) of our school children still leaves something, and in many cases much, to be desired. Despite the fact that the pre-school child is in many ways the most cared-for citizen, only one in five of our five-year-olds has had no dental decay: the average child aged five has four teeth missing, filled or decayed.

In some places one in ten of the children in our schools are educationally sub-normal, and—evidence of poor environment or poor parental care—one in ten children have head lice or nits.

Nutrition, of course, is a very complex matter which depends on much more than diet. Insufficient sleep, infectious diseases of childhood, lack of exercise, unhappiness, insecurity, all prevent a child from getting full advantage from his diet. Since less than half the mothers in Britain, however, get for their children the vitamin extras to which they are entitled, it is probable that the diet is not always as good as it might be. Nine-tenths of school children are now getting school meals, and there is little doubt that as a consequence we shall, over a period of years, see a considerable improvement in their nutrition; but, of course, no official provision is at present made, except in nursery schools, for well-balanced meals for the pre-school child. Although the school child gets one-third of a pint of milk a day entirely free of charge, milk for the pre-school child (except in cases of great need) has to be paid for, although at a cheaper rate.

It is certainly an indictment of our separation allowances for the dependants of Service men that the children of Service men showed a lower amount of hæmoglobin at all ages less than ten years.

Many of the 10 per cent of children who are educationally sub-normal are merely backward as a result of poor health or poor nutrition, so that here there is a close relation between the child's intellectual and physical health. Indeed, since in some cases a child may fail to use his intelligence principally because of emotional disturbances, emotional health is involved as well. The importance of emotional health is indeed recognized in the report, and developments of the Child Guidance Service are forecast. There are, too, throughout the report many indications of a clearer recognition of the child's unity of mind and body and of the consequent need for the closest possible co-operation between the teacher, doctor and nurse; and considerable space is given to a consideration of how physical education and health education can help.

The importance of the home and of factors outside the home is rightly stressed. However much school meals are developed, and other existing responsibilities of the parent taken over by the teacher or the school doctor or nurse, the health of the school child will still be largely determined by the care given

* The Health of the School Child. Report of the Chief Medical Officer of the Ministry of Education for the Years 1939–1945. Pp. 148. (London: H.M. Stationery Office, 1947.) 2s. 6d. net.

him in his home. Nevertheless, the extension of the school's responsibility increases the influence of the school in health as well as in education.

The whole report points strongly by implication to the need for a more dynamic and functional approach to school medicine.

One looks forward to the day when the school medical officer is an integral member of the school staff, whose duty it is to study the child at work and at play in the changing school setting. With its demands upon the child's senses and its opportunities for expression—intellectual, emotional and social—aspirations and powers, the school offers probably unique opportunity for the study of the functioning of the total child. The study of health in this dynamic sense would surely be much more profitable than the present sporadic and static methods of school medical inspection.

INDUSTRIAL FIBRES

BEFORE the Second World War, the Commonwealth Economic Committee issued annually a series of reviews which summarized the main facts of production, international trade and consumption for various important animal and plant commodities. These reviews are now being re-issued for the war and post-war years. Among the first to reappear is the volume on "Industrial Fibres"*, which surveys the world situation with regard to cotton, wool, silk, flax, jute, hemp, mohair, coir and rayon. While the data for several countries are not yet available, the information gives a broad indication of changing trade patterns. The main change has been the redirection of foreign trade caused by the dislocation of normal trading channels and the development of alternative sources of supply. The United Kingdom remained the chief importer of industrial fibres, although, after 1941, the United States imported most wool, some of which was accumulated as reserve on the United Kingdom's account. Imports into the main European countries and Japan were greatly reduced during the war years.

The world production of fibres at first expanded but soon declined sharply, reaching a minimum in 1944, with moderate recovery in 1946. Output was generally restricted to cover essential war purposes, and civilian consumption of textiles was curtailed. Where production exceeded demand, as in wool and cotton, stocks accumulated, thus increasing the supplies available in the post-war period. The recovery in 1946 continued in 1947, but future expansion will depend on changing conditions in Germany and Japan. There has been no significant modification in the post-war pattern of production of the different fibres compared with pre-war years, with the exception of rayon, which is now being mainly produced in the United States. Comparing production in 1945 with that in 1938, wool has declined least, namely, 2 per cent; rayon yarn has declined 11 per cent; cotton 26 per cent; staple rayon fibre 45 per cent; and silk 73 per cent. The serious decline in cotton production was caused mainly by the transfer of cotton-growing land to food production, particularly in India and the United States. Silk production was largely suspended in Japan during the War. In 1946, wool alone showed a small decline over the 1945 figure, but world stocks are still large. Rayon made good the war-time losses and rose 10 per cent above the 1938 figure. Cotton and staple fibre production also showed improvements but silk expanded only slightly, being in 1946 only 27 per cent of the pre-war figure.

The contribution made by the British Commonwealth to the world's production of fibres is considerable. Thus nearly all the world's jute, nearly half the world's wool, more than a quarter of all its hemp and nearly a fifth of its cotton are produced in the Commonwealth, which is still an exporter of these fibres, having built up surplus stocks before the War. The 1946 export balance for wool was the highest ever recorded; for jute and hemp it was about one-half of the pre-war figure. The war-time dependence on foreign supplies of rayon, silk and flax (imported on balance before the War) has now been lessened, but dependency on outside sources still applies to cotton.

The significance of industrial fibres in the exports of different Commonwealth countries has been amply maintained during the post-war period. For example, wool accounted in 1946 for 33 per cent of the total exports of South Africa, other than gold, as compared with 30 per cent in 1938 and only 6 per cent in 1944. Jute and jute products made up nearly 30 per cent of the exports from India in 1946, which were 24 per cent in 1938. Hemp reached 44 per cent of the exports from Tanganyika in 1946 as against 38 per cent in 1938.

Cotton. The main sources of cotton for world trade are the United States, India, Brazil and Egypt. In addition, Russia and China also grow large quantities of cotton but consume most of it domestically. The chief importers of cotton before the War were Japan and the United Kingdom, which used up nearly half the total production, other European countries consuming the rest. Production declined from 17,900 million lb. in 1938 to 10,000 million lb. in 1946, but consumption fell even more, so that stocks rose from 10,400 to 13,500 million lb., but have since fallen to nearly half this amount. Long-staple varieties are being increasingly grown in most of the chief areas.

Wool. This is produced as a main product in merino sheep farming or as a secondary product to meat in the rearing of crossbreds. A dry summer greatly reduces the output of fine merino wool. The rising trend in number of sheep before the War was reversed in 1941, and the decline was accentuated by the Australian drought of 1944–45. World production of wool fell rapidly after 1942, especially in the United States and Australia, and to a lesser extent in South Africa. Australia still retains its position as the leading wool-exporting country and usually exports more than twice as much wool as any other country. The chief importing country until 1941 was the United Kingdom, but since that year the United States has assumed first place. Lack of production statistics for *mohair* renders it difficult to assess the changes in world supplies over the war period.

Silk. Before the War, some 100 million lb., or 80 per cent, of the world's silk was produced in Japan. Since 1941, the production has diminished rapidly until, in 1946, Japan produced only 12 million lb. of raw silk. Even before the War, production was declining through increasing competition with rayon and nylon, which may eventually supersede natural silk.

* Industrial Fibres. Summary of Figures of Production, Trade and Consumption relating to Cotton, Wool, Silk, Flax, Jute, Hemp, Mohair, Coir and Rayon. Compiled in the Intelligence Branch of the Commonwealth Economic Committee. Pp. 137. (London: H.M. Stationery Office, 1948.)

Flax. The best flax is produced in temperate regions such as Europe. In certain countries, the plant is grown primarily for linseed, the fibre being a relatively expensive by-product. Reliable information concerning the world's flax industry is difficult to obtain because of this dual-purpose objective. The output of flax appears to have declined by some 70 per cent up to 1945 and has since shown only a moderate recovery. Considerable reduction in output has occurred in Russia, Poland, Belgium and Holland, whereas it has expanded in Egypt, Australia, New Zealand and Canada. Cotton, jute and rayon are proving to be serious competitors of flax, partly because of the high price of linen goods.

Hemp. The chief hemp-producing countries before the War were the Philippine Islands (manila bast fibre, used for marine cordage), the Netherlands East Indies and Tanganyika (sisal bast fibre, used for binder twine), Eastern Europe and Russia (true, leaf hemp, used for twine and cord). World output of bast (or 'hard') hemps fell considerably through the effects of the War in the Far East, although the output in Tanganyika was maintained, and of leaf (or 'soft') hemp in Europe and Russia through curtailment of the area on which the crop was grown.

Jute. Most of the world's jute is grown in Pakistan, but the greatly increased home demand for sacking has brought about a marked reduction in exports. The jute mills and the main port (Calcutta) are situated in the Dominion of India, and future development of the jute industry will depend on the conditions of inter-trade between the two new Indian Dominions. The largest importer of jute is the United Kingdom, although present stocks are low.

Coir. The only important world-producers of coir (coconut fibre) are India and Ceylon, where the industry is carried out as a part-time occupation of villagers, who also utilize a large proportion of the material. The mobilization of native labour for war purposes in these two countries has led to reduced coir production during the past eight years.

Rayon. The output of rayon yarn has been maintained in recent times, despite the collapse of Japan, by the large increase in production in the United States, which has more than doubled since 1941. By 1946, the United Kingdom had become the second largest producer and the second largest exporter. Rayon depends for its raw materials on the supply of wood pulp or cotton linters. The filaments are reeled to produce 'filament yarn' or spun on to spindles to produce 'staple fibre'. The former competes with natural fibres; the latter is an intermediate product which is becoming increasingly important as an admixture to the natural fibres.

OBITUARIES

Prof. F. A. A. Lacroix

On March 16 there passed out of the scientific life of Paris a great figure and one whose scientific writings have been read by mineralogists and geologists the world over for the past sixty years. François Antoine Alfred Lacroix, 'secrétaire perpetuel' of the Paris Academy of Sciences for thirty-four years and professor of mineralogy at the National Museum of Natural History during 1893–1936, was born at Maçon on February 4, 1863, and died in Paris on March 16. He studied at the *lycée* of his native town, at the Sorbonne, and at the Collège de France. He commenced to study pharmacy but soon was attracted to geology and mineralogy, and in 1887 was appointed 'préparateur' at the Collège de France and a collaborator on the French Geological Survey. Before he was thirty he succeeded Des Cloizeaux as professor of mineralogy at the Natural History Museum. He added many fine specimens of minerals and a superb collection of rocks to the Museum collections. In this he was assisted by many of his pupils, mining engineers and government officials in France's overseas possessions who, catching the enthusiasm of the master for his science, seem to have been ever ready to gather materials for his scientific work and for the national collections.

On his appointment to the Museum, Lacroix commenced at once a great work on the mineralogy of France and her Colonies: its fourth volume was completed in 1913. In these volumes he described the associations and paragenesis of the minerals as well as their crystallography and optical properties. A separate work in three volumes on the mineralogy of Madagascar was published in 1922 and 1923. This included a wealth of detailed petrology and many new analyses of rocks as well as descriptions of the minerals. In this book he developed his classification of igneous rocks, a modified form of the American quantitative classification. In later years he devoted more time to petrology than to descriptive mineralogy, and published a great many papers describing the rocks of many regions, and introducing, sometimes in very brief papers, ideas of considerable importance. Meteorites and tektites—the mysterious glass bodies supposedly of meteoritic origin—were also subjects of his research and were described in important memoirs. To geologists Lacroix will be best known for his early work on the granite of the Pyrenees and its contact phenomena (1898–1900), and for the well-illustrated memoirs recording his observations on active volcanoes in several parts of the world, including especially Mt. Pelée, Vesuvius and Réunion.

In addition to all his mineralogical work, Lacroix devoted an immense amount of time to the affairs of the Academy of Sciences, working at the development of its library and the classification and enrichment of its archives, gathering together letters and other documents of great interest. He published biographies of many mineralogists. His two-volume history of the life of Déodat Dolomieu appeared in 1921, and in 1928 a historical note on the distinguished occupants of the 'chair' of the section of mineralogy of the Academy from Nicolas Desmarest (1795) to Lucien Cayeux (1928).

In all his work Lacroix had a sympathetic and devoted companion in his wife, Catherine Fouqué, daughter of the geologist, Ferdinand A. Fouqué, with whom Lacroix worked in his early years. Madame Lacroix accompanied her husband on many of his travels, visiting with him many active volcanoes. Their married life was extremely happy, and their home had a charm which touched all who were admitted to their friendship and their hospitality. Madame Lacroix died in 1944 and Lacroix never completely got over it; but still he remained enthusiastic and immensely active, and went daily to the museum and the Academy. To the end of his life he was surrounded by devoted friends and colleagues. Many geological societies had done him honour during his life-time and many tributes have already been paid to his memory. The president of the Paris Academy of Sciences, in announcing Lacroix's death to the members, described him as a man who had

devoted his whole life to science and "qui restera dans la mémoire comme un des représentants les plus admirables de ce que peut donner, dans notre race, l'association d'un génie scientifique de premier ordre, avec un de ces caractères incorruptibles qui sont l'honneur de l'humanité". W. CAMPBELL SMITH

Dr. E. P. Harrison

DR. E. P. HARRISON, for many years professor of physics at Presidency College, Calcutta, and head of the Observatory, and later chief scientist to the Mine Design Department in H.M.S. *Vernon*, died suddenly at Chigwell Row, Essex, on May 6.

Born in London in 1877, he was the eldest son of Robert William Harrison. His school career was much interrupted by illness, but he entered University College, London, where he won the Clothworkers' Exhibition, and an 1851 Exhibition Research Scholarship in physics. From London he went to the University of Zurich, where he took a Ph.D. in science. In 1904 he went up to King's College, Cambridge, as an 'advanced student', and worked at the Cavendish Laboratory for two years. He lectured at King's College, London, and the Royal College of Science, Dublin, and was then appointed professor of physics at the Mahommedan College of Aligarh in India. Afterwards he was appointed to the Indian Educational Service, and became professor of physics at the Presidency College, Calcutta, and later, in addition, meteorologist to the Government of Bengal.

In 1923, he became chief scientist to the Mine Design Department, H.M.S. *Vernon*, a post which he held until his retirement under the age limit in 1937. His work during this period naturally received no publicity; but under his direction the application of scientific research to the problems of naval mining, begun in the First World War, under the inspiration of, among others, W. L. Bragg, F. E. Smith and G. W. Walker, was continued and extended, and the results he achieved bore good fruit when another war came. He was happiest when working in a laboratory, and never allowed the responsibilities of administration to keep him from active research.

Among Dr. Harrison's personal contributions to naval problems were pioneering work in the application of magneto-striction to the generation of high-frequency sound in water, and the investigation of various properties of the high-permeability alloys of the 'permalloy' group. Perhaps the most interesting of these are the very large changes of impedance which occur in a wire carrying audio-frequency A.C. when small longitudinal magnetic fields are applied to it. An account of fundamental work on this effect was published by Dr. Harrison and members of his staff in 1936, and a practical application was a novel form of magnetometer which was used before the War, in anticipation of the use by the enemy of magnetic mines and torpedoes, to explore the possibilities of controlling the magnetic fields of warships by current-carrying cables. This was probably the earliest practical essay in 'degaussing'. During the War the magnetometer was developed on behalf of the Admiralty by the Electrical Research Association, and became a standard measuring instrument on degaussing ranges.

On leaving the Admiralty, Dr. Harrison joined the staff of Messrs. Hughes and Sons, of Barkingside, and arranged to continue the work he had begun earlier on magneto-striction in H.M.S. *Vernon*. The original oscillators made by him were developed by the firm, and a large number of experiments were made with listening devices off Gourock pier, which led to increased sensitivity.

The outbreak of war attracted his attention to the detection of mines, either floating or submerged, by supersonics, and very valuable data were collected. Later he did much work, both in the laboratory and in trials at sea, on non-contact firing devices for torpedoes.

Dr. Harrison was a physicist in the classical tradition, and had a very keen brain which he applied with great zest to new technical arts of war and peace. He had a large circle of friends, and will be greatly missed for his constant kindness and help to young scientific workers.

NEWS and VIEWS

The King's Birthday Honours List

THE following names of men of science and others associated with scientific work are included in the King's Birthday honours list:

Baron: Sir Alfred Webb-Johnson, president of the Royal College of Surgeons.

K.B.E.: Sir Hector Hetherington, principal and vice-chancellor of the University of Glasgow; Acting Air Commdre. Frank Whittle.

Knights Bachelor: A. Leigh B. Ashton, director of the Victoria and Albert Museum; Dr. A. H. Gardiner, the well-known Egyptologist; Dr. C. R. Harington, director of the National Institute for Medical Research; Prof. C. N. Hinshelwood, Dr. Lee's professor of chemistry, University of Oxford; J. D. G. Medley, vice-chancellor of the University of Melbourne.

C.B.: H. M. Garner, principal director, scientific research (air), Ministry of Supply; N. H. Kinnear, director of the British Museum (Natural History); O. Thornycroft, director of aeronautical and engineering research, Admiralty.

C.M.G.: W. N. Allan, recently director of irrigation, Sudan Government; Dr. P. Stocks, chief statistician (med.), General Register Office; Dr. H. H. Storey, secretary of the Colonial Agricultural Research Committee.

C.B.E.: Prof. W. E. Agar, lately professor of zoology, University of Melbourne; H. H. B. Allan, director of the Division of Botany, Plant Research Bureau, New Zealand; Prof. J. H. Biggart, professor of pathology and dean of the Faculty of Medicine, Queen's University, Belfast; Dr. H. W. Cremer, president of the Institution of Chemical Engineers; Mrs. Maud E. Cunnington, for services to archæology; Prof. A. Findlay, emeritus professor of chemistry, University of Aberdeen, for services to chemistry; B. E. Frayling, Colonial Mines Service, lately chief inspector of mines, Nigeria; Lieut.-Colonel W. French, superintendent of the Technological Department, City and Guilds of London Institute; Dr. A. A. Griffiths, research engineer, Rolls-Royce, Ltd.; W. F. Higgins, superintendent of the Physics Division, National Physical Laboratory; Prof. W. R. Jones,

emeritus professor of mining geology, University of London (Imperial College of Science and Technology), for services to the Board of Trade; C. Kershaw, director of British Optical and Precision Engineers, Ltd., for services to the production of optical instruments; Dr. A. King, chief scientific liaison officer, Office of the Lord President of the Council; Prof. H. A. D. Neville, lately professor of agricultural chemistry, University of Reading; Miss Margery Perham, reader in Colonial administration, University of Oxford; Prof. J. Ritchie, professor of natural history, University of Edinburgh; Dr. H. V. Taylor, lately senior education and advisory officer, Ministry of Agriculture; S. G. Taylor, director of irrigation, Ceylon.

Sir James Chadwick, F.R.S.

Sir James Chadwick has been pre-elected Master of Gonville and Caius College, Cambridge, of which he has been a fellow and more lately an honorary fellow. Sir James began his scientific work under Rutherford in Manchester; after studying in the University of Berlin he was interned in Germany during the First World War, and there continued his scientific researches. When Rutherford moved to Manchester, Chadwick joined him and took part in Rutherford's classical researches on the disintegration of elements by α-particles. With Bieler and later with Rutherford he studied the scattering of α-particles by hydrogen and heavier nuclei, and from these experiments determined the law of force around atomic nuclei. He became assistant director of research under Rutherford at Cambridge, and as such was responsible for the training of Rutherford's young research students and for the satisfaction of their modest needs. Many nuclear physicists will remember the attic of the Cavendish equipped with ancient vacuum pumps, gold-leaf electroscopes and the simple apparatus for counting α-particles which was then the main tool of nuclear research. The discovery of the neutron in 1932, followed by the photodisintegration of the deuteron (with Goldhaber) and the creation of electron pairs by γ-rays (with Blackett and Occhialini), marked the peak of Chadwick's experimental work. In 1935 he was appointed Lyon Jones professor of physics in the University of Liverpool, and at once embarked on the construction of a 36-in. cyclotron, completing this just prior to the Second World War.

On the outbreak of war, Chadwick took up the study of nuclear chain reactions based on the fission of uranium, and with Frisch and Peierls informed the Government in the spring of 1940 that an atomic bomb could probably be produced if sufficient U235 were concentrated. Further studies of nuclear constants in Liverpool and Cambridge confirmed this view. At the end of 1943, Chadwick was largely instrumental in restoring the collaboration with the United States in atomic energy which was severed in 1941. He recruited a small but powerful British team to work in Los Alamos and Berkeley, and took a leading part with Dr. Mackenzie in establishing the Canadian Atomic Energy Project at Chalk River. Since the War he has served on the Scientific and Technical Committee of the United Nations Atomic Energy Commission. On his return to Liverpool he initiated the construction of a cyclotron to produce 300 MeV. protons. Chadwick's pupils in nuclear physics are distributed over the whole world. They will regret his severance from active experimental work but will all wish him well in the tasks which lie ahead.

Dr. E. D. Merrill

Dr. E. D. Merrill retires from the Arnold professorship of botany, Harvard University, at the end of June. As professor emeritus he is to remain in the house on the margin of the Arnold Arboretum that has been his as director of the Arboretum where, granted good health such as all his many friends wish him, he will enjoy the facilities for botanical study that have been so considerably shaped by him. Under him the inflow of material, living and dried, into the Garden and Herbarium from eastern Asia, Malaysia and the Pacific has been tremendous; and it is well that he should take a large part in elaborating it. Born on October 15, 1876, Elmer Drew Merrill passed in 1899 from College into the United States Department of Agriculture. In the Department he was selected (1902) for the appointment of government botanist in the Philippine Islands and went out to Manila, one of a few men chosen to start a science service towards which at that time there was nothing but a budgetary appropriation. It was soon evident that his methods were direct and effective. Botanical teaching was added (1912) to his work, and in 1918 the administration of the Bureau of Science. In 1923 the University of California sought and secured his service as dean of the College of Agriculture, where it was his duty to draw into order State-wide organisations that were growing up too loosely knit. In 1930 New York induced him to cross the continent to take the post of director-in-chief of the New York Botanic Garden. Institutions in the United States such as it, depend much on private generosity, and in bad times suffer checks to their activities: it is so in New York, and he had the years of the great depression to combat. It need be no secret that his successes in adjustment led to an invitation to move to Boston (1935) into a post made for him with the title of administrator of the Botanical Collections of the Harvard University and director of the Arnold Arboretum. The collections that passed under him had some likeness to the miscellany he set in order in California, at least in diversity. The University has rearranged these responsibilities; and his last, the teaching of advanced students in methods of research, passes elsewhere. He is now free to devote his time to botanical research.

Dr. L. H. Bailey

Dr. Liberty Hyde Bailey, eminent administrator, botanist, horticulturist and author, attained his ninetieth birthday on March 15. On this date he was actually on Arruba Island in the West Indies on one of his annual palm-hunting expeditions to tropical America. He was signally honoured on his return to Ithaca, New York, in May by a complimentary dinner sponsored by Cornell University, with which institution he has been associated for the past sixty years. On this occasion, with approximately two hundred guests in attendance from various parts of the United States, the speakers extolled Dr. Bailey's eminent services to Cornell University, to agricultural instruction, research and extension, to botany, to horticulture, and to the humanities. The outstanding feature of the evening was Dr. Bailey's informal address, which dealt with his early experiences and some of his later achievements. Tall, straight, speaking extemporaneously and without notes, it was indeed an inspiration to all who heard him on this occasion.

Bailey's career has been an extraordinary one. His father was an early settler in what a century ago was the wilderness of Michigan, and the son's early years were thus associated with the primitive conditions of pioneer life. Following his graduation from college in 1882 he served for several years as assistant to the eminent American botanist Asa Gray at Harvard University, and it was this experience, plus his personal interests, which determined his future career. He is the last living associate of Gray, who, in turn, was a frequent visitor to London and was the outstanding American exponent of the Darwinian hypothesis. Even when because of his special qualifications Bailey was selected as dean and director of agriculture at Cornell University in 1903, he accepted appointment only on the condition that he would be permitted to resign from administrative work at the end of ten years. He retired from academic work as emeritus professor of agriculture in 1921, but this did not mean quiescence on his part. His energies have since that date been devoted to his special botanical and horticultural interests, including the botany of cultivated beauty, an intensive study of North American *Rubus*, and a long-continued investigation of the palms and their classification; and it is this special interest in palms that has inspired him to make trip after trip to remote parts of Mexico, the West Indies and South America in recent years, with future ones already planned. In 1937 he presented his home, his library and his large herbarium to Cornell University, this unit being designated as "The Bailey Hortorium"; and of this he is still the director. His honours have been very numerous, for the value of his achievements has been recognized all over the world. Among these is foreign membership of the Linnean Society and honorary membership of the Royal Horticultural Society of London.

U.S. National Museum: Dr. A. Remington Kellogg

Dr. A. Remington Kellogg has been appointed director of the United States National Museum. Dr. Kellogg has been curator of mammals in the Smithsonian Institution for the past seven years. He is one of the leading experts on whales and whale-like animals. His doctorate thesis, dealing with cetacean palæontology, attempted to trace the ancestry of the earth's largest animals from their land origins. He has served as delegate for the United States on several international congresses dealing with whale conservation and had a leading part in the establishment of the great Antarctic whale sanctuary set up by international agreement. The National Museum, which Dr. Kellogg now will administer, is the largest of the Federal bureaux administered by the Smithsonian Institution. It is the storehouse of what now is probably the most extensive systematized natural history collections in the world, ranging from elephants to fossil insects. It contains large ethnological and historical collections and valuable series in the field of mechanics and inventions.

University of Cambridge

General Smuts was installed as chancellor of the University of Cambridge on June 10. He then conferred honorary degrees on the following, among others: Mr. Winston Churchill; Sir Stafford Cripps; Sir Hector Hetherington, principal and vice-chancellor of the University of Glasgow; Mr. Charles Seymour, president of Yale University; Mr. J. F. Cameron, master of Gonville and Caius College, Cambridge; Sir Hugh Lett, president of the British Medical Association; Sir Wilson Jameson, chief medical officer of the Ministries of Health and Education; Sir Richard Livingstone, vice-chancellor of the University of Oxford; Sir Robert Robinson, president of the Royal Society; Sir Paul Fildes, of the Medical Research Council; and Mr. Arnold Toynbee, director of studies in the Royal Institute of International Affairs.

National Federation of Educational Film Groups

The National Federation of Educational Film Groups recently held its first annual conference in King's College, University of London. Membership of the Federation now amounts to thirty-three groups, representing more than 2,500 teachers. The Federation aims at co-ordinating and assisting the activities of groups of teachers specifically organised to encourage and develop the use of visual aids to teaching, at stimulating the formation and development of such groups, and at collating and analysing the views and knowledge of those experienced in visual methods. Its work includes the development of a library of film strips and charts, the publication of surveys of existing films under specific subject headings, and the organisation of courses for the study of visual aids. The main resolution debated at the conference welcomed the plans of the National Committee for Visual Aids and reaffirmed the support of the Federation in the Committee's task of promoting the wider adoption of visual methods in education. Attention was directed to the need for breaking the "vicious circle of supply and demand in materials", to the importance of reducing production costs, and to the necessity of ensuring that units making educational films were at all times assisted by clear directives. It was decided to establish a fact-finding committee which should report to the Council of the Federation on matters concerning the production and distribution of visual aids.

The conference was also made the occasion of an exhibition housed in the large hall of King's College and designed to provide a wide selection of equipment and materials for visual presentation. Makers, producers and distributors of visual material and projectors had been invited to exhibit and nearly fifty had accepted. The range of exhibits included film and film strip projectors, film strips, wall charts and accessories. An ingenious arrangement of stalls made for the convenience of both exhibitors and visitors and allowed demonstrations to proceed simultaneously. A useful guide-book was available containing details of exhibits and available sources of supply. A nearby room was used for full-length projection of educational films and film strips. The exhibition was well attended, and stall-holders were kept busy throughout the day. The idea of combining conference and exhibition was certainly a happy one, and the organisers are to be congratulated on this and on the excellence of their arrangements.

Chemical Engineering and Fuel Technology at the University of Durham

Commencing in October 1948, King's College, Newcastle upon Tyne, will offer a two-year post-graduate course in chemical engineering leading to the degree of master of science in chemical engineering of the University of Durham. The course will be available to graduates in mechanical engineering or to those who possess some equivalent degree or qualification. The opportunity has been taken to

link with chemical engineering the teaching of fuel technology, which has hitherto been carried out by individual departments as required. The main subjects of study during the course will include, in the field of chemical engineering, materials of construction and the design of chemical plant, the flow of fluids and the transfer of heat and matter and the various unit operations. The fuel technology course will include the fuel industries, steam, power and industrial gases. A series of lectures will also be given on the economic, legal, health and safety aspects of chemical engineering. Practical work will be carried out in a new fuel technology laboratory and in a new chemical engineering laboratory which will house a number of small-scale plants.

British Museum (Natural History)

THE first three sections of a new exhibition in the central hall of the British Museum (Natural History), South Kensington, dealing with viruses and virus diseases have been opened. The exhibition has been planned in collaboration with Dr. K. M. Smith, of the Plant Virus Research Station, Cambridge. The effects are shown of virus infection in animals and plants (for example, foot-and-mouth disease, and tobacco mosaic disease), and modes of virus transmission both by direct contact and by means of insects are illustrated. Further exhibits in this series which are in preparation will cover the subjects of virus 'carriers' and the study of viruses in the laboratory.

Colonial Service Appointments

THE following appointments in the Colonial Service have been announced: W. Finalayson, assistant conservator of forests, Tanganyika; R. R. H. Horsley, inspector of mines, Malaya; R. L. Rodda, inspector of mines, Nigeria; A. H. Foster, veterinary officer, Malaya; J. P. Knowles, veterinary officer, Nigeria; A. D. Swan, assistant meteorologist, West Africa; E. G. Waller, temporary agricultural survey officer (cocoa), Gold Coast; G. W. Anderson (agricultural officer, Kenya), agricultural officer, Zanzibar; W. J. Badcock (senior agricultural officer, British Solomon Islands Protectorate), chief soil conservation officer, Nyasaland; R. K. Kerkham (agricultural officer, Uganda), senior agricultural officer, Uganda; T. Y. Watson (senior agricultural officer, Kenya), deputy director of agriculture, Uganda; F. B. Wilson (agricultural officer, Zanzibar), agricultural officer, Kenya; A. C. Brooks (senior chemist, Singapore), chief chemist, Federation of Malaya; A. W. Burtt (senior chemist, Federation of Malaya), chief chemist, Singapore; W. D. Raymond (Government chemist, Medical Department, Tanganyika), Government chemist, Tanganyika.

Browne Research Fund of the Royal Society

THE Council of the Royal Society is prepared to consider applications for financial assistance from research workers at marine biological stations or universities in Great Britain who desire to visit Bermuda for periods of three to six months to carry out a specific programme of work at the Bermuda Biological Station. Applicants should state the nature of the research proposed, the sum required, including an estimate of any loss of salary incurred during absence, and give the names of not more than two referees who will support the application. In accordance with Mr. Browne's bequest, preference will be given to those who propose to work on purely scientific problems. As a guide to possible applicants, the special interest of the present director of the Station, Dr. D. E. S. Brown, lies in the effects of high-pressure on the physics and chemistry of biological functions, for which the deep water off Bermuda provides unique facilities. Applications for grants required for the period ending April 1949 should reach the Assistant Secretary, Royal Society, Burlington House, London, W.1, not later than September 1, 1948.

Announcements

SIR ALEXANDER FLEMING, professor of bacteriology in the University of London, has been awarded the Grand Cross of Alfonso X, and has also received an honorary degree from the University of Madrid.

THE following appointments in the University of Oxford have been announced: Mr. D. G. Champernowne, reader in statistics in the University, to be professor of statistics; Prof. J. Jewkes, Stanley Jevons professor of political economy in the University of Manchester, to be professor of economic organisation.

M. ROBERT COURRIER has been appointed 'secrétaire perpétuel' for the physical sciences of the Paris Academy of Sciences in succession to the late Prof. Alfred Lacroix (see p. 962 of this issue of *Nature*).

THE Commissioners of the Exhibition of 1851 announce the following awards of senior studentships for 1948: D. H. Perkins, for research in nuclear physics at the Imperial College of Science and Technology, London; J. H. Westcott, for research in electrical engineering at the Imperial College of Science and Technology, London; A. R. Pinder, for research in organic chemistry in the University of Oxford; N. Reynolds, for research in botany at University College, Cardiff. The awards are of the value of £500 a year (exclusive of allowances), and are tenable for two or three years.

A CONFERENCE of the British Society for Research on Ageing will be held on July 7, from 11 a.m. to 6 p.m., at the Royal Society of Medicine, London. Papers will be read by Sir Frederick Bartlett and Prof. E. C. Dodds, and Drs. F. Bourliere, L. Cosin, F. Denz, E. Geiringer, V. Korenchevsky and O. Olbrich. The Conference will be open to all who are interested in gerontology.

THE Trustees of the Lady Tata Memorial Fund announce that, on the recommendation of the Scientific Advisory Committee in London, they have made the following awards for research in blood diseases, with special reference to leukæmia, at the places mentioned, in the academic year beginning on October 1, 1948: *Grants for research expenses and assistance:* Dr. Marcel C. Bessis (Paris); Dr. Jörgen Bichel (Aarhus); Dr. Pierre Cazal (Montpellier); Dr. Johannes Clemmesen (Copenhagen); Dr. Peter A. Gorer (London); Dr. Andrew Kelemen (Szeged); Dr. Edith Paterson (Manchester); Prof. Edoardo Storti (Pavia). *Scholarships (for whole-time or part-time research):* Dr. Simon Iversen (Copenhagen); Dr. Claus F. M. Plum (Copenhagen); Dr. Guido H. R. Tötterman (Helsinki).

A CONGRESS of Genetics was held at the Centro di Genetica del Consiglio Nazionale delle Ricerche in Pavia during April 2–4. We understand that the *Proceedings* will be published shortly; a monograph on the biology of about a hundred species of insects more or less suitable for genetical researches is also being planned.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Anomalous Effects in Ionospheric Absorption

In current methods of vertical sounding of the ionosphere by radio waves, two relationships are usually experimentally determined, namely, (1) the value of the equivalent height of reflexion (h') as a function of radio frequency (f); and (2) the value of the attenuation ($\log \rho$) as a function of frequency f. (Here ρ is the experimental value of the overall ionospheric reflexion coefficient.)

Using the vertical incidence (h', f) relation, which expresses the refractive properties of the ionosphere, it has been found possible to predict, with fair accuracy, the refractive influence of the ionosphere on waves obliquely incident on it. In this case the

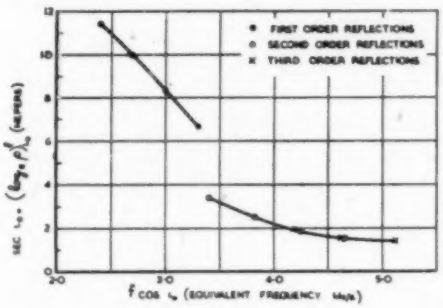


Fig. 1

relations between any two of the three variables, h', f and i_0 (where i_0 is the angle of incidence of the radio beams on the ionosphere), may be predicted when the other quantity is assigned a constant value. There has, however, been no such corresponding success in predicting the absorptive behaviour of the ionosphere for obliquely incident waves, using the ($\log \rho$, f) relation as determined for the conditions $i_0 = 0$. Indeed, under certain conditions, which we describe below, a most flagrant disagreement is found between the predictions of oblique-incidence absorption based on commonly accepted radio theories and the results found in practice.

Some years ago, Martyn[1] introduced the useful conception of equivalent frequency into theoretical relationships between vertical-incidence and oblique-incidence phenomena, by showing how it was possible to relate in simple fashion the absorption of a wave of frequency f, impinging on the ionosphere at an angle of incidence i_0, with the vertical incidence absorption of its equivalent frequency, defined as $f \cos i_0$. Martyn's absorption equivalence theorem can be written as follows:

$$\sec i_0 \, [\log \rho]^{f}_{i_0} = [\log \rho]^{f \cos i_0}_{0}. \qquad (1)$$

In some radio pulse experiments conducted during the War between Burghead (Scotland) and Slough, over a distance of 715 km., measurements were made of $\log \rho$, using F-layer reflexions, for different values of f and i_0. To test how far these results support the relation (1), we have plotted, in Fig. 1, $[\log \rho]^{f}_{i_0}$ sec i_0 as a function of $f \cos i_0$. If the results satisfied relation (1), we should expect all the points to lie on a single curve. The diagram shows, however, that, although second-order and third-order echoes are indicated by points which lie on the same curve, the points indicating first-order (and thus the most obliquely incident) reflexions do not also lie on that curve. There seems indicated, in fact, either abnormally heavy attenuation of the singly reflected echoes or else abnormally weak absorption on the higher orders. That the anomaly is the former rather than the latter is, however, shown in the following table, where the actual attenuations for the singly reflected F-layer echoes are compared with the values calculated from vertical-incidence absorption data using Martyn's relation (1), given above.

PREDICTED AND EXPERIMENTAL VALUES OF IONOSPHERIC ABSORPTION AT OBLIQUE-INCIDENCE (ORDINARY-RAY COMPONENTS)

Date	Frequency (Mc./s.)	Observed absorption of first-order F-echoes (nepers)	Predicted absorption (nepers), based on Martyn's theorem and vertical incidence data
Dec. 27, 1944	4·3	2·82	1·29
	4·53	2·42	1·11
	4·78	2·06	0·96
	4·9	1·94	0·91
	5·2	1·90	0·84
	5·42	1·22	0·85
	5·65	1·43	0·85
Dec. 28, 1944	4·3	1·49	0·71
	4·52	1·48	0·79
	4·78	1·69	0·74
	5·42	1·83	0·96
	5·65	2·24	0·76

We have detected a similar large discrepancy between the ionospheric absorption observed over a long-distance communication circuit and that predicted from normal incidence absorption data.

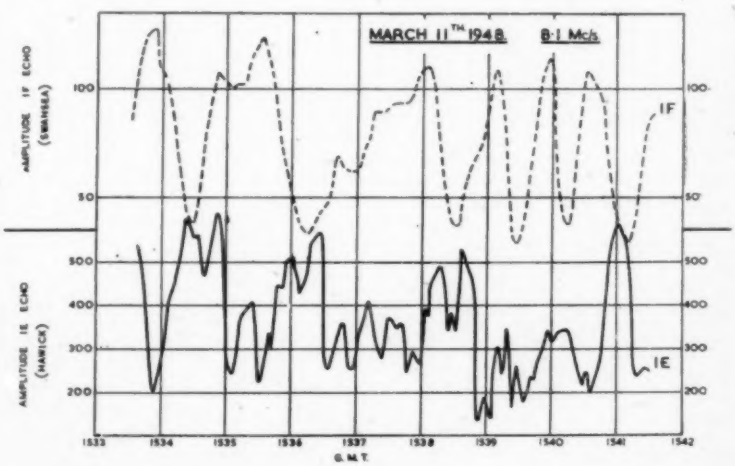


Fig 2.

It is therefore clear that there is some attenuating agency operative which is neglected in the physical basis underlying the formulation of Martyn's relation. Now Martyn assumed that the process of attenuation was that brought about by the ionospheric electron collisions with the air molecules. His theorem is also limited in applicability to conditions in which the frequency of such electronic collisions is small compared with the angular frequency of the radio waves and in which the influence of the earth's magnetic field on absorption can be neglected. In attempting to trace the source of the discrepancy described above, we have attempted to generalize the theorem so as to widen its applicability in the above two respects, but have found that the modified expressions do not account for the anomaly.

We have thus been forced to conclude that there is an agency of attenuation operative which is additional to that caused by electronic collisional friction. In this connexion we may note that under the conditions of our experiment, and indeed in many practical cases too, the frequencies used were only slightly in excess of the oblique-incidence critical frequency for the *E*-layer, which the radio waves traverse on their journey to and from the *F*-layer. This fact has led us to suspect that the additional attenuating agency might be the scattering or partial reflexion of the waves by abnormal or sporadic *E*-layer ionization, the effect of which, as can easily be shown theoretically, is not predicted quantitatively by Martyn's theorem.

To test this hypothesis, experiments have recently been carried out to see whether there is any correlation between sporadic *E*-layer reflexions and the attenuation of waves which pass through that layer. From a pulse sender situated near Frazerburgh, Scotland, *F*-layer first-order echo amplitudes were observed at Swansea over a distance of 685 km. It was estimated that the radio waves on their upward journey to the *F*-layer would pass through the scattering and partially reflecting centres of the *E*-layer at a distance of about 130 km. from the sender. Simultaneous observations of the amplitude of sporadic *E*-layer echoes were therefore made at double this distance, namely, at Hawick. In Fig. 2 are shown plotted some temporal variations of signal amplitudes observed at the two sites, from which it is seen that, when the strength of sporadic *E*-layer echoes at Hawick increases, the waves reflected by the *F*-layer suffer substantial attenuation. It is therefore clear that deviation by sporadic *E*-layer ionization may sometimes have an important influence on the amplitude of waves reflected by the *F*-layer, and we interpret these results as supporting our conclusion concerning the identification of the origin of the discrepancy mentioned above.

A fuller account of these and other absorption measurements and their interpretation will be published elsewhere. The work has been carried out as part of the programme of the Radio Research Board of the Department of Scientific and Industrial Research.

E. V. Appleton
W. J. G. Beynon
W. R. Piggott

Dept. of Scientific and Industrial Research,
24 Rutland Gate, London, S.W.7.
May 7.

[1] Martyn, D. F., *Proc. Phys. Soc.*, **47**, 323 (1935).

Theory of Superconductivity

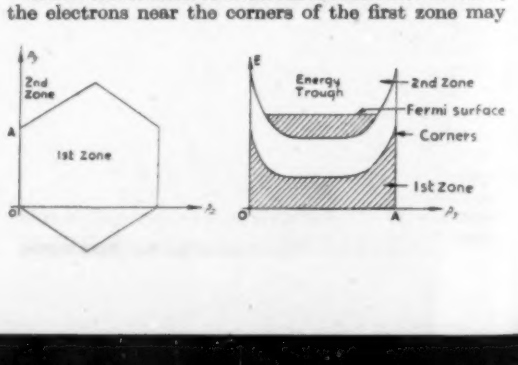
It is a controversial question whether the phenomenon of superconductivity is merely a consequence of the quantum theory of interaction among electrons or whether it depends on the specific crystal structures. The first point of view is taken in Heisenberg's theory[1]. However, it can be shown by general reasoning that if the ionic forces between ions and electrons are disregarded, all states with a total current different from zero will have higher energy than those without. Moreover, there is a strict isomorphic correspondence between all states without current and all states with a given current. Consequently the free energy of the states with a current cannot be the smallest at any temperature. Secondly, Heisenberg's theory predicts the existence of superconductivity in all metals, including the alkali metals; yet so far experimental evidence does not confirm this.

On the other hand, we have found an empirical rule that indicates a correlation between superconductivity and lattice structure; namely, that those metals are superconductive for which the Fermi surface, supposed to be a sphere, lies in very close proximity to one set of the corners formed by the boundary planes of a Brillouin zone. The following table shows the different ratios of the radius of the Fermi surface and the distance from the origin to those corners, for most of the superconductive elements and for some of the non-superconductive elements.

Lattice type	Superconductive elements		Non-superconductive elements
Body-centred cubic	V, Ta, βZr	1·03 and 0·98	Li, Na, K, Rb, Cs, $\leqslant$0·75
Face-centred cubic	Al, βLa, βTl, Th, Pb(?)	1·008	Ca, Sr $\leqslant$0·88 Au, Ag, Cu $\leqslant$0·7
Close packed hexagonal	Zn	0·927	
	Cd	0·925	
	αTl	1·10	
	αLa	1·098	

This table encourages the view that a correct theory of superconductivity should be based on the ionic forces. It is known that these ionic forces have predominant influence on the behaviour of the electrons, if the Fermi surface is close to the boundary planes of the Brillouin zone. Now if the Fermi surface nearly circumscribes a complete Brillouin zone, it is certain that the circumscribed zone is full and the next zone is partially filled. The accompanying figure gives a rough sketch of the aspect of a plane (E, p_y), where E is the energy and p_y the component of the momentum along one side of the polygon representing a cross-section through a Brillouin zone. The energy surface $E(\mathbf{p})$ has a discontinuity along this plane which is largest at the corners O, A, and small between them. Hence if interaction of electrons is neglected, the first zone is filled up to the corners, while the second zone is partially filled at the bottom of the energy trough.

If now interaction of electrons is taken into account, the electrons near the corners of the first zone may



migrate into the trough of the second zone, or vice versa. One has to investigate which of these possibilities happens, and whether the symmetry in momentum space of the arrangement is not so disturbed as to produce a mean momentum (current). Among these correlation forces the Coulomb exchange force between electrons with parallel spins is the largest, as, according to the calculation of Wigner and Seitz[2] for the dissociation energy of sodium and lithium, the exchange energy is nearly four times as large as the correlation energy between electrons of antiparallel spins. For simplicity consider a unit volume of metal. We can now estimate the energy required to pick out n electrons from a filled corner and redistribute them in the trough on top of the Fermi surface. Let $\mathbf{p}_0$ be the momentum corresponding to the highest energy-level in the corner. Then the energy of a single electron with momentum $\mathbf{p}$ in the neighbourhood of $\mathbf{p}_0$ is

$$E(\mathbf{p}) = E(\mathbf{p}_0) - \frac{1}{2m^*}(\mathbf{p}_0 - \mathbf{p})^2, \qquad (1)$$

where m^* is the effective mass, generally small for the electrons near the top of a broad band[3]. For the assembly of electrons one has to consider further the interaction described above. Let ω_0 be the number of corners which can be assumed to lie symmetrically in the momentum space, and let $n_1, n_2, \ldots n_{\omega_0}$ be the numbers of electrons removed from the corresponding corners. The calculation gives for the total change of energy

$$\Delta E = \sum_i n_i \left\{ \varepsilon_0 - \frac{3}{4}e^2\left(\frac{3}{\pi}\right)^{1/3} n_i^{1/3} + \frac{3}{5}\left(\frac{3}{\pi}\right)^{2/3} \frac{\hbar^2}{2m^*} n_i^{2/3} \right\} + \frac{\hbar^2}{8\pi m}\left(\frac{\pi}{3n_0}\right)^{1/3}\left(\sum_i n_i\right)^2, \qquad (2)$$

where n_0 is the mean density of electrons. The constant ε_0 and the last term with $n_i^{2/3}$ in the bracket come from the kinetic energy (1), the middle term with $n_i^{2/3}$ from the exchange energy, and the last term with $(\sum_i n_i)^2$ from the filling up the free Fermi surface.

From (2) one calculates the minimum value of ΔE, varying the occupation numbers $n_1 \ldots n_{\omega_0}$. The result shows that it is possible to have a state of lowest energy such that, out of ω_0 corners, only $\omega(<\omega_0)$ are 'excited', which means that a number of electrons n ($\sim 10^{-4}\, n_0 \sim 10^{18}$) are removed from each corner and redistributed on the free Fermi surface, while the remaining $\omega_0 - \omega$ corners are intact. The magnitude of $n \sim 10^{-5} n_0$ obtained is easily understood by observing that the minimum of ΔE must be near that value of n where the two terms with $n_i^{2/3}$ and $n_i^{1/3}$ in the bracket cancel, that is, where (using the Bohr radius $r_1 = \hbar^2/me^2$)

$$l \equiv n^{-1/3} = \frac{8\pi^2}{5}\left(\frac{3}{\pi}\right)^{1/3}\frac{m}{m^*}\left(\frac{\hbar^2}{me^2}\right) = 9{\cdot}8\,\frac{m}{m^*}r_1. \qquad (3)$$

Now it is known that $m^* = \frac{1}{5}\,m$, hence $l \sim 50\, r_1$, and $n = (50\, r_1)^{-3} \sim 10^{-5}\, n_0$, as the size of the cell is of order $r_1{}^3$.

An asymmetric occupation of the corners represents a state with a resultant momentum and therefore with a spontaneous current.

One has now to determine the thermodynamical properties of this state. The free energy can be calculated by taking account of the thermal agitation of electrons transferred to the free Fermi surface, their thermal energy being equal to $\frac{\omega}{\omega_0}\frac{2\pi^3 m}{3h^2}\left(\frac{3n_0}{\pi}\right)^{1/3} k^2T^2$. The transition temperature T_c is defined by $\omega = \omega_0$, because when this state is reached the asymmetry and hence superconductivity disappear.

Thus one finds

$$T_c = \sqrt{\frac{3}{8}} \cdot \frac{n\omega_0 h^2}{\pi^2 km}\left(\frac{\pi}{3n_0}\right)^{1/3} \qquad (4)$$

and $T_c \sim 1°$ K., if for n the value 10^{18} previously obtained is substituted. The change of specific heat on passing the transition temperature T_c is found to be approximately

$$\Delta C = \frac{4\pi^3 mk^2}{3h^2}\left(\frac{3n_0}{\pi}\right)^{1/3} T\left(\frac{3T^2}{T_c^2} - 1\right). \qquad (5)$$

The formula agrees with one obtained empirically by Kok[4].

We have made a preliminary investigation of the electrodynamics of superconductivity and found that the length $l = n^{-1/3}$ represents the depth of penetration of a magnetic field in a superconductor as introduced by London. The theoretical order of magnitude $l \sim 10^{-6}$ cm. agrees with the requirement of measurements. The detailed theory will be developed by one of us (K. C. C.).

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March 25.

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[4] Kok, *Physica*, 1, 1103 (1934).

An Anomaly in Electromagnetic Theory

IN a paper which is being issued as a scientific report by the Defence Research Board, Ottawa, and which may be published elsewhere later, I have shown that it is impossible by means of the Maxwell–Lorentz theory of electromagnetism to obtain a reasonable or consistent result for the following problem.

If an electric charge in uniform motion passes near a stationary closed conducting loop, the magnetic field of the charge will link the loop, and hence an E.M.F. and current should be induced in the loop as the charge passes by. If, however, the loop moves and the charge is stationary, with the same relative motion as before, Maxwell – Lorentz theory gives zero-induced E.M.F., and it is shown that this result is not affected by the magnetic effects of the charges induced by the stationary charge on the surface of the moving coil.

The induction of a current in the first case, however, is inconsistent with the principle of the conservation of energy, since although the coil experiences the correct electromagnetic reactive force, the electromagnetic force on the moving charge is perpendicular to its direction of motion, and hence no work is required to maintain its prescribed motion.

The electromagnetic theory of Ritz is shown to give equal finite E.M.F.s in the two cases, but again the principle of conservation of energy is violated.

There appear to be only two possible ways of escape from the energy dilemma. Either no E.M.F.

can be induced or the electromagnetic force on the charge must have a component opposing its motion. The first possibility seems scarcely credible, since the facts of electromagnetic induction by the relative motion of two constant-current circuits, coupled with the electronic theory of conduction, present convincing evidence that an E.M.F. *should* be induced in this problem. The second possibility is contrary to the usual interpretation of Ampère's experiment, in which he found that a current-carrying wire could not be moved longitudinally by a neighbouring magnet or current. It is shown, however, that since the *current-path* in the movable wire in Ampère's experiment could not move, it is not possible to find out by means of such an experiment whether an electrically neutral current-element, or a single moving charge, can experience a longitudinal magnetic force or not. The existence of a small longitudinal force is not, therefore, inconsistent with experiment, and seems to provide the only possible solution of this anomaly of energy conversion.

It appears that the problem is amenable to experimental test, and a practicable arrangement for the apparatus is described. It is shown that the effects of electrostatically induced charges on the coil should not obscure the main effect.

It would appear that only a relative-velocity theory of the type developed in a preliminary way by Ritz can give a reasonable result for this problem. The description of the behaviour of high-speed charged particles by Ritz's theory, however, is different from that given by classical relativistic electrodynamics. For example, Bucherer's classical experiment is explained by Ritz without any variation of the mass of the electron. The problem, therefore, seems to be of considerable fundamental significance to physical science. The special theory of relativity does not appear to resolve it, since relativistic transformations confirm that a magnetic field, and hence an E.M.F., should exist in one case but not in the other.

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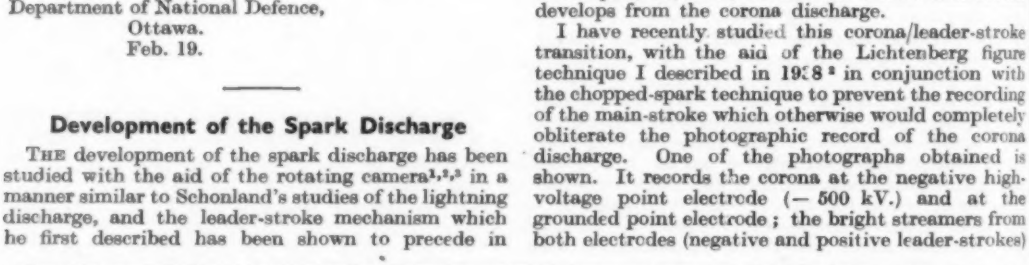
Development of the Spark Discharge

The development of the spark discharge has been studied with the aid of the rotating camera[1,2,3] in a manner similar to Schonland's studies of the lightning discharge, and the leader-stroke mechanism which he first described has been shown to precede in similar manner the main spark discharge in air at atmospheric pressure. Schonland[4] suspected that the stepped leader discharge was not advancing into wholly un-ionized or virgin air, and suggested that it travelled along a pre-existing ionized path, the path of a 'pilot streamer', which probably moved from cloud to ground with the effective velocity of the stepped leader process, say, 10^7 cm./sec. He failed to record this pilot streamer—if it exists—photographically.

In the laboratory I found[2] it very difficult to photograph all that the eye could see of the discharge process between a point electrode at, say, one million volts to ground, and a plane earthed electrode, even with the aid of a quartz-rock salt lens of wide aperture. This fact was not sufficiently emphasized[3] in Allibone and Meek's[3] account of the process, so that Bruce[4] has suggested that the leader-stroke might be formed from a diffuse glow discharge of the kind which is plainly visible in some of our rotating camera photographs and described as a "shower of discharge".

There is no doubt that a faint and very extensive corona discharge precedes the concentrated bright streamer which is readily photographed: I studied this corona carefully in complete darkness in 1931, though I did not describe it when the branching of the negative spark discharge was described[4]. In 1938[2] I published the best photograph (Fig. 2 of that paper) that I had succeeded in taking in 1931: the corona discharge was seen to extend over the whole of a 4-ft. gap between electrodes, although the concentrated bright streamer (now called the leader-stroke) never exceeded 25 per cent of the gap length. This corona discharge and the leader-stroke can be seen quite easily if precautions are taken to prevent complete spark-over, which is so blinding to the eye; the use of a spark gap having the requisite time-lag placed in parallel with the gap under observation is the customary means of achieving this, and, by careful control, the leader-stroke in the gap under observation can be chopped at various periods of its development. Normal photographic techniques, however, do not show how this leader develops from the corona discharge.

I have recently studied this corona/leader-stroke transition, with the aid of the Lichtenberg figure technique I described in 1938[2] in conjunction with the chopped-spark technique to prevent the recording of the main-stroke which otherwise would completely obliterate the photographic record of the corona discharge. One of the photographs obtained is shown. It records the corona at the negative high-voltage point electrode (— 500 kV.) and at the grounded point electrode; the bright streamers from both electrodes (negative and positive leader-strokes)



are both evident. Many observations have first been made without the photographic paper bridging the gap, and it can be stated beyond doubt that the presence of the paper makes very little difference, if any, to the appearance of the discharge. Details of the corona playing over the surface of the emulsion are far superior to any details which can be photographed through a lens: indeed, with a lens, practically only the leader-strokes would have been recorded.

I am certain now that the missing 'pilot streamer' is corona discharge similar to that shown in the photograph; that the leader-stroke develops behind this faint corona and is in the nature of a 'core' to the voluminous corona shower, a trunk and a few main branches in relation to the tree with its innumerable small branches and twigs. Why this is stepped in the lightning flash is still a matter for study; that it is stepped in the laboratory may be due mainly to the circuit; the terminal voltage may be diminished by the current taken by the leader-stroke, but the present experiments do not elucidate this, so further experiments are in progress.

I wish to thank Dr. F. J. Miranda and Mr. F. E. Chivers for assistance in these experiments, and the Metropolitan-Vickers Electrical Co., Ltd., for the loan of the portable impulse generator: also Dr. W. A. Berry, of Messrs. Ilford, Ltd., for the photographic papers selected for use.

Note added in proof. The printed record is inferior to the photographic record, which shows the corona bridging the gap.

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[6] Schonland and Allibone, *Nature*, **128**, 794 (1931).

Time (min.)

PORTION OF THE PEN RECORDER TRACE COVERING THE 12TH TO THE 18TH MINUTE OF A 30-MIN. RECORDING.

ORDINATE: E.M.F. EQUIVALENT AT INPUT TERMINALS TO THE VALVE UNBALANCE

Low-Frequency Noise from Thermionic Valves Working under Amplifying Conditions

ALTHOUGH there is a great deal of information concerning the noise produced by thermionic valves at radio frequencies, there do not appear to have been published data for the low-frequency noise intensity they produce under amplifying conditions. It has long been known that the noise intensity increases as the frequency to which the observational system is tuned is diminished, and a theory of the origin of this so-called 'flicker' noise has been given by Schottky[1] and modified by Macfarlane[2]. One of us (E. J. H.) has made measurements of valve noise and found that the intensity of the low-frequency noise varies approximately inversely as frequency in the range 10–1,000 c./s. At 1,000 c./s. it was not observable above the 'shot' noise. If expressed as an equivalent fluctuation E.M.F. at the grid, the low-frequency noise was remarkably constant from valve to valve.

Those observations, however, do not suffice to allow calculation of the performance of a direct-coupled amplifier covering a band of zero to (say) 1,000 cycles, as it is the very low-frequency fluctuations which set a limit to the useful amplification. It is, of course, difficult to distinguish between fluctuations arising in the valves, and those resulting from irregularities in the external circuits; but the figure for the low-frequency noise which we have obtained using a particularly well-stabilized direct-coupled amplifier sets an upper limit to the valve noise integrated over the band zero—1,000 cycles. A balanced system using 6J6 valves with input shorted produces fluctuations having a maximum amplitude equivalent to 20 μV. (peak to peak) when observed on an oscilloscope over a period of several seconds. Using a moving coil pen recorder it has been possible to obtain an accurate record of the low-frequency fluctuations over a period of 30 min. (see record above). The maximum peak-to-peak fluctuation in the record was about 60 μV. One result of the concentration of the noise of the zero frequency end of the spectrum is that extending the band-width to cover 0–5,000 cycles does not appreciably increase the total valve noise.

When a 2·2 megohm resistance was connected across the input the thermal agitation noise (6 μV. r.m.s. for a 1,000-cycle band-width) of the resistance could be seen to increase the mean noise-level (observed in a short period) by some 50 per cent.

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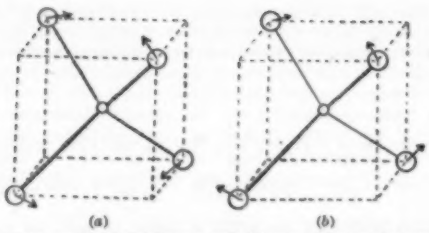
[1] *Phys. Rev.*, **28**, 74 (1926).
[2] *Proc. Phys. Soc.*, **59**, 366 (1947).

A Correlation between Molecular Vibrations and Bond-forming Orbitals

IN a recent letter, Heath and Linnett[1] suggested for the treatment of molecular vibrations a new force field, the orbital valency force field. This is based more closely on modern ideas of directed valency than is the simple valency force field. We decided to test the orbital valency force field on methane, which is a convenient molecule to use, since all the deuterium-substituted methanes have been studied[2]. The first result obtained was that the original theory failed in this case. In particular, for CH_4 and CD_4, it was found that, to explain the frequencies of the doubly degenerate bending vibrations, a bending constant (k_H/r^2) of $1{\cdot}35 \times 10^5$ dynes/cm. was required, whereas the triply degenerate bending vibrations needed a constant of $0{\cdot}86 \times 10^5$ dynes/cm. Bending motions which are members of these two degenerate sets are shown in the accompanying drawings.

The relative values of these two bending constants indicate that it is easier to bend the molecule in the sense of Fig. *b* than in the sense of Fig. *a*.



(a) (b)

(a) THE DOUBLY DEGENERATE, AND (b) THE TRIPLY DEGENERATE BENDING VIBRATIONS OF METHANE

The bond-forming orbitals of the carbon atom in methane are sp^3 hybridized giving four equal bonds[3]. It can be shown that the hybridization of these orbitals can be changed so that the orbitals alter their directions in a manner similar to the vibration shown in Fig. *b*, but that they cannot change their hybridization to alter their directions in a manner similar to Fig. *a*. It appears, therefore, that the bending shown in Fig. *b* is easier than that shown in Fig. *a*, because the bond-forming orbitals of the carbon atom can, by changing their hybridization, partially follow the hydrogen atoms during vibration *b*, but not during vibration *a*.

This means that we need two constants to describe the bending: (i) an orbital bending constant measuring the force tending to restore the hydrogen atom when it is moved away from the line along which the carbon bond-forming orbital has its maximum value (k_H); (*b*) an orbital following constant measuring the increase of energy when the bond-forming orbitals are distorted by change of hybridization (k_β).

If $\Delta\alpha$ is the bending of the four C—H directions from their original orientation at a certain stage of the vibration in Fig. *b*, and $\Delta\beta$ is the angle through which the orbitals have followed this movement, we may write for the potential energy

$$2V = 4k_H (\Delta\alpha - \Delta\beta)^2 + k_\beta \Delta\beta^2,$$

since $(\Delta\alpha - \Delta\beta)$ is the angle between the distorted C—H direction and the new direction in which the orbital has its maximum value[4].

The value of $\Delta\beta$ will be that which makes the energy a minimum. By differentiating V with respect to $\Delta\beta$ and equating the differential to zero, we can eliminate $\Delta\beta$:

$$2V = \frac{4k_H k_\beta}{4k_H + k\beta} \Delta\alpha^2.$$

When k_β is infinite, there is no orbital following, and the above expression for the potential energy reduces to the simple orbital valency force field expression:

$$2V = 4k_H \Delta\alpha^2.$$

But if k_β is not infinite, $k_H k_\beta/(4k_H + k_\beta)$ is less than k_H, that is, distortion is easier.

This type of force field has been applied to CH_4, CH_3D, CH_2D_2, CHD_3 and CD_4 using three constants: valency stretching constant $k_r = 4{\cdot}95 \times 10^5$, $k_H/r^2 = 1{\cdot}362 \times 10^5$ and $k_\beta/r^2 = 12{\cdot}98 \times 10^5$ dynes/cm. With these three constants it is possible to explain the fourteen stretching vibration frequencies with an average error of 0·81 per cent and a maximum error of 2·15 per cent, and to account for the fifteen bending vibration frequencies with an average error of 1·19 per cent and a maximum of 2·44 per cent.

The merit of this force field is that, not only does it account for the twenty-nine vibration frequencies of these molecules, but also it accords well with the wave-mechanical conception of the bond-forming orbitals of the carbon atom. It introduces a relation between the distortion of the bonding orbitals and the molecular vibrations, which means that information regarding these distortions can be obtained from molecular vibration frequencies. It is hoped to apply similar ideas to other molecules.

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Feb. 17.

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Electrical Resistivity of Alkali Metals Below 20° K.

THE change of the electrical resistivity of pure metals at temperatures below 20° K. is of considerable theoretical importance. While there is available a great body of experimental data at the temperatures of liquid hydrogen and helium, only one set of experiments[1] exists in the intervening region, which covers a 5 : 1 ratio in absolute temperature. Since for most metals the resistance becomes largely independent of temperature below 4° K., this region (between 4° and 20° K.) is crucial for determining the law of resistance variation with temperature. We have now modified a previously described helium cryostat[2] working on the Simon expansion principle for continuous work between 1·5° and 20° K., temperatures being determined by a gas thermometer, and the electrical resistance with a sensitive galvanometer amplifier[3].

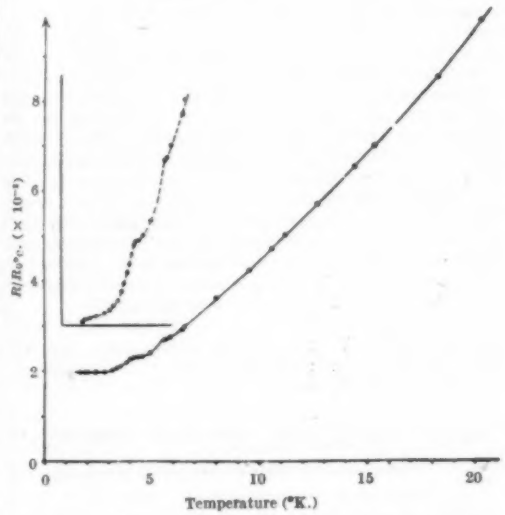
	Lithium	Sodium	Potassium	Rubidium	Caesium
n	4·52	4·85	3·2	2	(1·4)
Θ	350	200	160	80	(50)
$^nR_\Theta$	5·0	4·9	4·9	3·5	(2·4)
$\frac{^nR_\Theta - {}^nR}{^nR_\Theta}$	0·1	0·01	0·35	0·43	(0·42)
$\frac{\sigma}{M\Theta^3}.V^{1/3}$	30·4	70·1	54·8	53·9	57·8

The whole alkali metal group has now been surveyed, and a short summary of the results is given in the accompanying table. Subtracting the temperature-independent residual resistance, in accordance with Matthiessen's rule, n represents the apparent power variation with temperature deduced from logarithmic plots of the [illegible]. According to Bloch's theory[4], n should be 5: the deviation of the lattice vibrations from the Debye T^4 law has, however, to be taken into account. Using Grüneisen's formula[5] in conjunction with the Debye characteristic temperatures, Θ, a corrected value of the theoretical power variation $^nR_\Theta$ (appropriate to each metal) can be derived for the region concerned. It appears that agreement between observation and theory only obtains in the case of sodium. An estimate of the

degree of deviation $(n_\theta - n)/n_\theta$ is given in the fourth row of the table.

Bloch's theory (and Grüneisen's formula) will only be expected to be valid where the Fermi surface is a sphere in k-space as is generally assumed for the monovalent metals. Our results seem to indicate that, except for sodium, the Fermi surfaces of the alkali metals are distorted. A critical survey of other physical data on the alkali metals—for example, the reduced conductivity at 0° C., $\frac{\sigma}{A\Theta^2}V^{1/3}$—appears to strengthen this assumption. Distortion of the Fermi surface in the case of lithium may possibly be due to insufficient screening of the valency electron; in the case of the higher alkalis, to the effect of electrons from the lower shells.

The parameters for cæsium appear in parentheses because, besides the general deviation from the expected power law, two definite 'kinks' in the resistance curve appear in the neighbourhood of 4° K. (see graph), leaving a degree of uncertainty in the residual resistance, etc.



ELECTRICAL RESISTANCE OF CÆSIUM AT LOW TEMPERATURES. *Inset.* RESISTANCE ON MAGNIFIED SCALE; TEMPERATURE SCALE UNCHANGED

Similar anomalies between 9° K. and 14° K. were observed with potassium. The obvious explanation of an experimental error in the temperature measurement was obviated by various control experiments. In the case of cæsium the suspicion that the anomalies might be caused by inclusion of mercury, superconductive below 4·1° K., was removed by chemical and spectrographic analysis. Furthermore, the high purity of the samples, which were obtained by redistillation, is indicated by the relatively low residual resistance. Another batch of cæsium from the same source showed a distinctive kink in the resistance curve at ~ 10° K., while the anomaly at ~ 4° K. was much less marked. Preliminary investigations on the variation of resistance in transverse magnetic fields (up to ~ 4 kG.) at 4° K. and 2° K. also yielded curves with analogous anomalies. In this connexion it is of interest to note that Meissner and Voigt[6] from their measured values on cæsium at 4° K. and 20° K. suspect a discontinuity in the resistance-temperature curve in the intervening range.

On the strength of the evidence before us, we cannot suggest an adequate explanation for these anomalies. The different behaviour of our two samples of cæsium suggests some sort of dependency on structure; it is worth remembering that superconductivity, too, exhibits structure-dependent features which are particularly strong in the less well-investigated metals such as vanadium, titanium and uranium. It appears possible, further, that these anomalies in the electrical resistance may be related to small anomalies in the specific heat, such as were observed in beryllium by Cristescu and Simon[7] and in sodium by Pickard and Simon[8].

A detailed account of this research will be published elsewhere. The investigation on the alkali metals is intended as the first part of a survey of the low-temperature resistivity of pure metals in general, and work is now in progress on the second column of the Periodic Table.

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[6] Meissner and Voigt, *Ann. d. Phys.*, **7**, 761 (1930).
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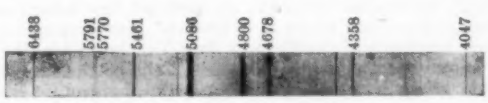
A Simple Way of Photographing Spectra

RECENTLY, I have been photographing spectra in their natural colours with 35 mm. Dufaycolor film. The spectra were produced by a single 60° flint prism. 35 mm. film is used in a camera of 5 cm. focal length and, if this camera had been used by itself, the spectra would have been much too short. I therefore tried to photograph them through the telescope of the spectrometer; that is, the telescope object glass and eyepiece were left in position and the camera placed immediately after the eyepiece. The telescope had a magnification of about 11 times, so this would increase the angular extent of the spectrum from 2½° to 27½°. I found that the field of view of the spectrometer eyepiece was too narrow, but on substituting the eyepiece of a prismatic field-glass which took in a cone of semivertical angle 128′ instead of the previous 53′, the experiment succeeded; the visible spectrum covered the full breadth of the film and was in perfect focus from end to end.

The method is naturally not restricted to colour film, and the accompanying photograph shows what can be done by it with the Ilford Special Rapid Panchromatic plate and an exposure of three minutes. In this case a 3½ in. × 2½ in. plate was used length-



ways and the spectrum occupied the full length of the plate. The wave-lengths are marked in angstroms. Any camera will do. The eye-ring of the telescope is only 2½ mm. in diameter and about 9 mm. out from the end of the telescope, so a lens working at $F/16$ is ample. The spectrum is focused with the telescope, and the camera is focused on infinity; so it does not require a focusing arrangement. Not only is the spectrum in focus from end to end of the plate, but also the latter gives the theoretical value for the resolving power all over it. The spectrum is that of the cadmium mercury arc.

It is almost impossible to discover anything new in optics nowadays, and someone is probably using this method at the present time. But I have seen no reference to it anywhere, and I have never seen or heard of a spectrometer with a wide-angle eyepiece. So I think it worth while to direct attention to the possibilities of the method here. It replaces the spectrograph for many purposes and opens up an interesting new field to experiment.

Some hints may be added. If a crown glass prism is used, the spectrum extends to 3500 A. But the ultra-violet portion is out of focus, the object glasses not being corrected for this region. Several spectra may be obtained on the same plate by tilting the camera or (not so good) by tilting the prism table. It is not possible to use the snapshot shutter of the camera for quantitative work; there are no sources bright enough. If the wide-angle eyepiece is used without the camera, but with a very wide slit, the arrangement is very suitable for projecting spectra and making them visible to a class; in this case the screen should be about three feet from the eyepiece.

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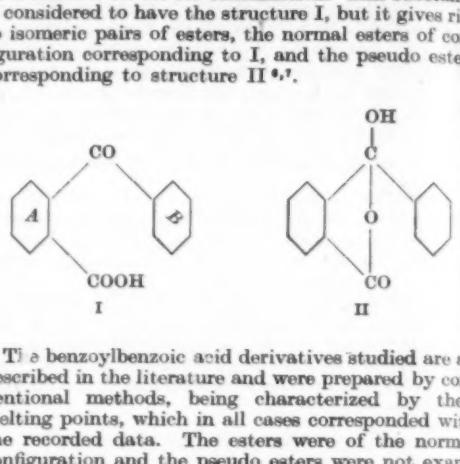
Differential Effect of 2-Benzoylbenzoic Acid and its Derivatives upon Plant Species

At the time of the discovery of the selective herbicidal activity of (i) the substituted phenoxyacetic acids[1,2] and (ii) the arylcarbamic esters[3,4], many other chemical types were examined, and 2-benzoylbenzoic acid and its derivatives received considerable attention because of their marked biological activity[5]. The investigation of this type was at the time abandoned because of the superior promise of the phenoxyacetic acid derivatives as agents for the practical control of crop weeds. It is felt desirable, nevertheless, to place our observations on record, for it is our view that as the study of the subject develops, increasing numbers of different types of chemicals will be found to display selective herbicidal action, and the recording of data will contribute to the ultimate understanding of the relationships between chemical constitution and herbicidal effect.

2-Benzoylbenzoic acid and many of its derivatives are readily accessible chemicals since they are employed in the synthesis of anthraquinone derivatives. Since auxin-like activity, as well as the selective herbicidal effect which it is believed may depend on this biochemical function, is found in aromatic and heterocyclic carboxylic acids in which the carboxylic acid group is attached through a linking group to a cyclic nucleus, 2-benzoylbenzoic acid appeared to be a suitable choice for examination. This substance is considered to have the structure I, but it gives rise to isomeric pairs of esters, the normal esters of configuration corresponding to I, and the pseudo esters corresponding to structure II[6,7].



The benzoylbenzoic acid derivatives studied are all described in the literature and were prepared by conventional methods, being characterized by their melting points, which in all cases corresponded with the recorded data. The esters were of the normal configuration and the pseudo esters were not examined. The preparation of 2 : 4 : 5-trichlorophenylacetic acid has been described by Sexton[8].

The biological methods employed were described by Templeman and Sexton[2] and consisted of a laboratory germination test at a concentration of 200 parts per million of test substance in water, and a soil test. The acids were examined as sodium salts and the esters in dispersed form, prepared by dissolving them in a little alcohol and pouring into a large bulk of water. In the soil test, oats and charlock were sown together in boxes in the open, the chemical being applied in dry form diluted with sand at a rate equivalent to 25 lb. per acre. α-Naphthylacetic acid was used as a standard of comparison.

In accordance with the method previously used, the activities of the various compounds against charlock are recorded relative to that of α-naphthylacetic acid, as follows:

Class A: Substances of greater activity than α-naphthylacetic acid.
2 : 4 : 5-Trichlorophenylacetic acid.

Class B: Substances approximately equal in activity to α-naphthylacetic acid.
2-(4′-Chlorobenzoyl) benzoic acid.

Class C: Substances of some activity but less active than α-naphthylacetic acid.
2-Benzoylbenzoic acid.
2-(3′ : 4′-Dichlorobenzoyl) benzoic acid.
2-(4′-Chloro-3′-nitrobenzoyl) benzoic acid.
2-(α-Naphthoyl) benzoic acid.

Class D: Substances of low or doubtful activity or inactive.
Methyl 2-benzoylbenzoate.
Ethyl 2-benzoylbenzoate.
2-Benzoyl-4-(5)-chlorobenzoic acid.
2-Benzoyl-4 : 5-dichlorobenzoic acid.
2-Benzoyl-3 : 4 : 5 : 6-tetrachlorobenzoic acid.
2-(2′ : 5′-Dichlorobenzoyl) 3 : 6-dichlorobenzoic acid.
2-(2′ : 5′-Dichlorobenzoyl) 3 : 4 : 5 : 6-tetrachlorobenzoic acid (damage to oats).
2-(4′-Chloro-3′-aminobenzoyl) benzoic acid.
2-(4′-Methylbenzoyl) benzoic acid.
2-(4′-Chloro-α-naphthoyl) benzoic acid.
Phenylacetic acid.

In the seed germination test, it is known that the susceptibility of charlock and the resistance of oats is a characteristic response to β-indolylacetic acid, α-naphthylacetic acid and the substituted phenoxyacetic acids. Further, as all these chemical types produce characteristic effects such as epinastic responses on mature plants, it would appear that the mechanism of growth-inhibition of charlock may be

concerned with hormonal defunction. 2 : 4 : 5-Trichlorophenylacetic acid also fits into this picture, for an epinastic response of oat coleoptiles on emergence was observed, and it is a powerful inhibitor of charlock seed germination. Preliminary experiments have indicated that a response in the Went pea test is given by one of the more active members of the benzoylbenzoic acid series, namely, 2-(3′ : 4′-dichlorobenzoyl) benzoic acid; but the generality of the parallelism between the effect on charlock and auxin-like activity cannot be asserted until a more comprehensive examination has been made of these and other compounds.

Veldstra[9] has put forward the hypothesis that the biochemical effects of auxin-like substances have a physical basis, and that activity is found in substances in which an acidic group is bound to a cyclic nucleus in such a way that the direction of the negative pole lies at an angle (ideally, at right angles) to the plane of the ring. The activity of the benzoylbenzoic acids is not inconsistent with this hypothesis when it is borne in mind that the benzoyl radical can rotate freely about the bond uniting it to the benzoic acid nucleus (*A* in formula I), so that there is the possibility of the —COOH group projecting at an angle to the plane of the benzene ring (*B*) of the benzoyl group. It is perhaps significant that the weighting of this particular ring (*B*) alone by appropriately disposed chlorine atoms does not decrease the activity. Indeed, the activity was definitely increased in one case. A similar weighting of the ring *A* with which the —COOH group is coplanar reduced the activity.

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An Improved Method for the Assay of Toxicity of Arsenicals

Since the pioneer work of Durham, Gaddum and Marchal[1] on toxicity tests for arsenicals, comparisons have been carried out using the method of quantal responses. The statistical implications of this method have been the subject of a considerable volume of work[2–4]. No amount of perfection of analysis can, however, compensate for the inherent shortcomings of the method.

In a quantal response assay, each animal can contribute only a positive or a negative reading (in this case death or survival) to the total information obtained. In the event of the death of an animal, there is no indication as to whether the dose given was the exact minimum individual lethal dose for that animal, or whether, in fact, it was considerably in excess of this amount. Thus the method is usually wasteful of information when a continuous variate such as survival-time can be employed instead, and only where no such continuous variate can be used in an easily measurable form is recourse to quantal response methods necessary.

In the case of the arsenicals there seems to be no such difficulty. Using the survival-time as the continuous variate, it has been found possible to perform an assay with increased speed, accuracy, and economy in animals. Where the survival-time for each animal is used in this way, a definite numerical estimate of the toxicity of the drug for that particular animal has been obtained, and, provided that a linear dose-response relationship can be employed, it is naturally to be expected that more information will be gained per animal used in the test.

With this principle in mind a series of experiments was carried out. The same standard preparation of 'Neoarsphenamine' was used throughout, 'Neoarsphenamine' being one of the most widely used of all the arsenicals. The experiments were so designed that the methods of quantal responses and direct measurement of survival-times could be compared. The dose range in the latter case was chosen to ensure that all the animals treated should die, and that the longest period of survival should not exceed 10 hours. It was found possible to establish a linear relationship between dose of drug and mean survival-time when a logarithmic transformation of both was used. Statistical analysis of the results shows the graded response method to be accurate and unbiased. The accompanying table shows the calculated approximate limits of error for both types of assay, and for varying numbers of animals in the test. It is assumed in each case that the slope of the dose-response line is accurately known.

Method of assay	Minimum approximate percentage limits of error ($P = 0{\cdot}05$)		
	$n = 10$	$n = 20$	$n = 40$
Quantal response	77·5–129·0	83·4–119·7	88·1–113·6
Graded response	86·0–116·2	90·3–110·7	93·2–107·3

The limits of error for the graded response assay are thus about half as wide as those for the quantal response assay, and the accuracy of the estimation of potency is about four times as great. Trial assays have been performed on this basis with satisfactory results.

Although for the practical purpose of safeguarding against the issue for sale of highly toxic material the standard quantal response assay method may be satisfactory, it is hoped that this alternative method will be of value in those cases where a greater degree of accuracy is desirable. Work on these lines is still in progress and will be published in more detail at a later date.

Grateful acknowledgment is due to Dr. C. W. Emmens for his advice throughout the course of this work.

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Reaction of β-Naphthol with *l*-α- and *l*-β-Phellandrene

SOME years ago, Goodway and West[1] reported that low yields of the maleic anhydride adduct corresponding to α-phellandrene were obtainable from β-phellandrene, and it was considered probable that the *l*-α-phellandrene adduct isolated was derived by the thermal decomposition of the primary resinous material obtained from the *l*-β-phellandrene.

In attempts to obtain another derivative characteristic for β-phellandrene, we have studied the reaction of this terpene with β-naphthol and obtained a product which melted at 137–138°, whereas Salfeld[2] obtained a product melting at 139–140° from a sample of α-phellandrene of which the constants were not recorded. The *l*-β-phellandrene utilized in our experiments was derived from Canada balsam oil which has been shown to be free from the α-isomeride[3], and the *l*-α-phellandrene used for comparison was prepared by fractionation from the oil of *Eucalyptus dives*. From the melting point, mixed melting point, and optical rotation of the reaction products of the two terpenes with β-naphthol, the adducts appear to be identical. Further evidence of the identity and structure of the adducts is being sought, and in view of the fact that the infra-red absorption spectra[4] of α- and β-phellandrene offer the best possibility of distinguishing readily between the two terpenes, it is hoped that it may be possible to establish the mechanism of the reaction of the β-isomeride with β-naphthol.

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Inhibition of Hexosediphosphatase by Sulphhydryl Reagents and by Ascorbic Acid

DURING the course of an investigation of the action of vitamin K and its biological antagonists (dicoumarol, salicylate) on various phosphatases, details of which will be published elsewhere, it was observed that liver hexosediphosphatase[1] exhibited a much greater sensitivity towards quinones than did the other phosphatases. Purified bone phosphomonoesterase[2], for example, required a concentration of 10^{-3} *M* benzoquinone for complete inactivation, whereas 10^{-5} *M* benzoquinone was sufficient completely to inhibit the hexosediphosphatase.

It is well known that enzymes the activity of which is dependent on free —SH groups are inhibited by quinones in very low concentrations, and it has been suggested that the antibiotic activity of quinones is a result of this effect[3]. With the exception of some pyrophosphatases and transphosphorylases, the phosphatases, the activity of which is probably dependent on free amino-groups[4], are, on the other hand, not affected by —SH reagents[5]. The comparatively high quinone sensitivity of hexosediphosphatase, however, led us to examine the behaviour of this enzyme towards other substances which are known to react with thiol groups.

Our experiments show that hexosediphosphatase is inhibited by iodoacetate, by phenyl mercuric nitrate and by alloxan. Cysteine, which itself inhibits in sufficiently high concentration but strongly activates at lower concentrations, completely reverses the iodoacetate and phenyl mercuric nitrate inhibitions and partly reverses that by alloxan. Thus inhibition by iodoacetate (10^{-3} *M*) or by alloxan ($2{\cdot}5 \times 10^{-3}$ *M*) is 40 per cent. Cysteine (10^{-3} *M*) reactivates the iodoacetate-inhibited enzyme 100 per cent and the alloxan-inhibited enzyme 37 per cent (that is, inhibition is reduced from 40 to 25 per cent). Inhibition by alloxan (5×10^{-3} *M*) is complete and there is no reactivation by cysteine. Phenyl mercuric nitrate (10^{-4} *M*) inhibits 100 per cent, with complete reactivation by cysteine ($2{\cdot}5 \times 10^{-4}$ *M*). Cysteine (5×10^{-4} *M* and 1×10^{-3} *M*) alone activates 98 and 96 per cent respectively, while an increase in concentration to 5×10^{-3} *M* results in complete inactivation.

The hexosediphosphatase used was prepared as described by Gomori[1] and was free from non-specific phosphatase activity. Mixtures (10·0 ml.) of the enzyme solution (0·1 ml.), borate buffer (2·0 ml.), 0·05 *M* magnesium sulphate (2·0 ml.), sodium hexosediphosphate solution (2·0 ml. ≡ 0·2 mgm. phosphorus) and inhibitor were incubated for 30 min. at 37° and *p*H 9·1 in separate tubes, and the inorganic phosphate in each was determined colorimetrically. The quantity of enzyme used was such that half the substrate was hydrolysed in the controls (that is, no inhibitor) during the period of incubation. No phosphate was liberated in the absence of enzyme. When iodoacetate was used, it was incubated with the diluted enzyme-magnesium-buffer mixture for 15 min. before addition of the substrate and of cysteine.

Experiments with ascorbic acid, which was expected to activate the enzyme by virtue of its reducing properties, showed it to be a very powerful inhibitor. Concentrations below 5×10^{-7} *M* resulted in slight activation (up to 5 per cent), but concentrations greater than 10^{-6} *M* inhibited, with complete inactivation in the presence of 2×10^{-3} *M* ascorbic acid. This inactivation by ascorbic acid is undoubtedly due to competition with the hexosediphosphate, as indicated by the results of experiments with varied substrate concentrations. Results of a typical experiment are given in the accompanying table.

Ascorbic acid, molar concentration × 10^6	Substrate solution (ml.)	Inorganic phosphorus (μgm.)	Inhibition (per cent)
0	1·5	573	0
2·5	1·5	371	35
5	1·5	317	45
5	3·0	245	32
10	3·0	200	45
0	3·0	360	0

These results also confirm Gomori's observation that the substrate itself inhibits the enzyme as the concentration is raised and, for this reason, the amount of enzyme solution used was increased to 0·15 ml. in the above experiment.

Inhibition of β-malt amylase by ascorbic acid and related compounds was attributed by Hanes[6] to the presence in the molecule of the di-enol grouping. Giri[7] has shown that several plant and animal phosphatases, which were not affected by ascorbic acid, were inhibited by an ascorbic acid-copper complex. Our experiments demonstrate that ascorbic acid may

compete for an enzyme with a substrate which it resembles in ring structure. The possibility that ascorbic acid may compete with hexose diphosphate for other enzymes such as aldolase or with other furanose-sugar phosphates, and thereby influence the course of carbohydrate or nucleotide metabolism, seems to us to be worthy of further investigation.

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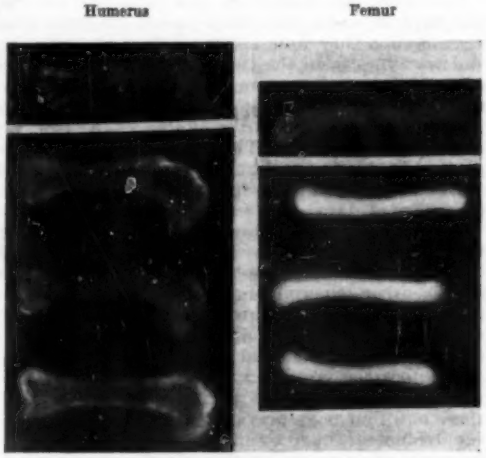
Influence of Folliculin on Bone Metabolism, Studied by Means of Radiophosphorus, $^{32}_{15}P$

In these experiments, all pigeons received daily 0·15 mgm. phosphorus labelled with radiophosphorus (subcutaneously) and 80 mgm. phosphorus provided by a normal diet (principally Indian corn). In addition, all pigeons, except control birds, received daily 0·25 mgm. œstradiol dipropionate ('Ovocycline P' Ciba, intramuscularly). The radiophosphorus was prepared by irradiations of phosphorus with deuterons produced by the cyclotron of the Laboratoire de Chimie Nucléaire of Paris (Prof. F. Joliot-Curie).



Upper photographs: controls
Lower three photographs: effect of folliculin

The right-hand autoradiograph was taken after a 20-day treatment; it shows the femur of a control pigeon and those of three pigeons submitted to folliculin administration. The new medullary bone is very rich in injected radiophosphorus; the quantity of the latter present in the control femoral diaphysis, however, is clearly perceptible. It appears, indeed, according to the determination of radioactivity by means of a Geiger–Müller counter, that the new medullary bone contains on an average seven or eight times more injected radiophosphorus than the femur of a control pigeon. As it can be seen from the left-hand autoradiograph, the mineral metabolism of bones such as the humerus, the medullary cavities of which are not filled with folliculinic bone, is, however, accelerated under the influence of œstradiol; radiophosphorus takes the place of phosphorus in the diaphysis as well as in the epiphysis to a greater extent in the treated pigeon than in untreated ones.

By calculating the amount of ordinary phosphorus from food and of phosphorus from parenteral administration (radiophosphorus), by measuring the rate of elimination of both forms of phosphorus and the quantity of these two elements present in bone, we have found that nearly half the phosphorus present in new medullary bone does not come directly from phosphorus fed or injected, but from phosphorus already stored in the skeleton. The proportion of labelled phosphorus observed at the end of a 20-day experiment shows that nearly 13·1 per cent of bone phosphorus (femur) has been renewed in a pigeon receiving folliculin, but only 1·7 per cent in the controls.

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Sublittoral Seaweed Survey: Relationship of Algal Growth and Depth

During the current survey of seaweed of the sublittoral zone of Scotland, very extensive sampling has been carried out. The samples are taken by means of a calibrated spring grab which closes by trigger action on touching bottom. The seaweed samples are weighed, species noted and also the depths from which they are obtained.

A survey of the sublittoral zone around the Argyllshire coast[1] has shown that a straight-line relationship exists between the mean density (d_f) of the total number of sampling operations and the depth:

$$d_f = 5{\cdot}48 - 0{\cdot}34\,f,$$

where d_f is density (kgm./m.^{2}) and f is depth (metres).

Laminaria Cloustoni is the dominant species. No large brown algæ were found below nine fathoms.

With the data obtained from the survey of Argyllshire, it was estimated that more than one million tons of seaweed was likely to be found growing in Orkney waters. Surveys to date indicate this figure to be conservative.

The results of surveys in Scapa Flow, Orkney (800 acres), have again shown that a straight-line relationship occurs between mean density and depth:

$$d_f = 6{\cdot}95 - 0{\cdot}41\,f.$$

Laminaria Cloustoni is the dominant species, and the density of seaweed growth is greater than on the coast of Argyll. No very strong tidal streams occur in either of these two above areas.

Two separate and extensive surveys have been carried out on opposite sides of Wide Firth, Orkney, namely, the Bay of Firth (1,500 acres) and around

the island of Shapinsay (3,000 acres). *Laminaria saccharina* is dominant in both areas.

Unlike the formula above, it is found that the square root of the mean density of total sampling operations divided by the percentage cover is approximately a constant :

$$\frac{\sqrt{d_t}}{C} = k,$$

where d_t is mean density of total sampling operations, and C is cover (number of samples with weed expressed as a percentage of total number of sampling operations).

For Bay of Firth

$$\frac{\sqrt{d_t}}{C} = 3{\cdot}04 + 0{\cdot}10f\ (\pm 4\%)\ 1\text{–}6 \text{ fathoms L.W.}$$

For Shapinsay

$$\frac{\sqrt{d_t}}{C} = 4{\cdot}06 - 0{\cdot}07f\ (\pm 4\%)\ 1\text{–}7 \text{ fathoms L.W.}$$

Very strong tidal streams are associated with Wide Firth.

A recently completed survey of Sanday Sound (8,300 acres), involving more than 2,500 sampling operations, showed a similar formula to that found for Bay of Firth and Shapinsay. *Laminaria saccharina* is the dominant species in these two areas, whereas *Laminaria Cloustoni* is dominant in Sanday Sound as in Scapa Flow.

The value for Sanday Sound is

$$\frac{\sqrt{d_t}}{C} = 3{\cdot}05 - 0{\cdot}02f\ (\pm 5\%)\ 1\text{–}10 \text{ fathoms L.W.}$$

Now $d_t = d_w C$.

$$\therefore\ \frac{\sqrt{d_t}}{C} = \sqrt{\frac{d_w}{C}},$$

so that $d_w \propto C$,

where d_t is mean density of total sampling operations, d_w is mean density of sampling operations which brought up weed, and C is cover expressed as percentage.

It follows, therefore, for Bay of Firth, Shapinsay coast and Sanday Sound, where very strong tides occur, that seaweed density (d_w) is directly proportional to the cover of the whole area, and in Scapa Flow and around the Argyllshire coast, where strong tidal streams do not occur, the mean density (d_t) of the whole area is inversely proportional to depth.

In the former cases $d_t \propto C^2$ and in the latter case $d_t \propto 1/f$.

Variations from the constant, $\frac{\sqrt{d_t}}{C}$, are due to small differences in the weights of individual plants.

Sampling has shown that at 4 and 5 fathoms in the Bay of Firth and Shapinsay, the *number* of plants and not their individual weights is chiefly responsible for great differences in mean density. The number of plants is found to be exactly proportional to the cover of the whole of the survey areas :

	% Cover at 4 and 5 fathoms	No. of plants/unit area
Bay of Firth	41	2·5
Shapinsay	77	4·7

The most interesting points brought out in these surveys of the sublittoral zone is that seaweed density of the larger brown algæ and the depth at which they grow conform to two simple mathematical laws : (1) that where strong tidal forces occur, the density of algæ is proportional to the weed coverage of the *whole* area. This can be accounted for by reproduction and spore dispersal ; (2) that where strong tidal forces do not occur, the density is inversely proportional to the depth at which the algæ grow.

Full details will be published later.

The above surveys are part of the programme of research of the Scottish Seaweed Research Association.

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Transplantation of Fertilized Rabbit Ova : the Effect on Viability of Age, *in vitro* Storage Period, and Storage Temperature

In 1890 and 1897, Heape[1] demonstrated the unimportance of somatic tissue to the germ cells by his successful transplantation of rabbit ova to a uterine foster mother. In 1934, Pincus and Enzmann[2] obtained normal young by transplanting rabbit ova fertilized or cultured *in vitro*. Recently[3], I reported normal development of ova stored at low temperature, and an optimal temperature for storage. I now have data on the probability of normal development after various treatments.

Ova were obtained from superovulated rabbits[4], and kept in undiluted rabbit serum. 25 hours after insemination they were recovered from the oviducts, and were mostly in the two-cell stage. If recovered after 72 hours they were mostly morulæ, some in the oviducts and some in the uterus. At 96 hours they were nearly all in the uterus, some being at the blastocyst stage. The ova were either transplanted fresh, or stored at 0° C. (slow cooling over a five-hour period) or at 10° C., or cultured at 38° C. (subcultured daily), before transplantation.

Recipient does were caused to ovulate by gonadotrophin injection. In one series of experiments, fresh 25-hour ova were transplanted to the uterus. In all the other experiments (most of which are summarized in the table), irrespective of the period of culture or storage, ova one day old at recovery were transplanted to the oviducts of does injected one day before the operation, while ova three and four days old were put into the uteri of does injected three and four days previously. Ova were placed in the oviducts through the fimbria, and into the uterus by puncturing its wall with a pipette containing the ova. Each host doe received five to twenty ova, the average number being increased with the length of time the ova were kept *in vitro*.

Most of the pregnant recipient does were killed 25–28 days after the operation. Some fœtal degeneration is normal in the rabbit[5], and young dead *in utero* (about 6 per cent of all young) were taken to represent normal development. The sex of live young, the number of maternal placentæ (ova implanted but failing to develop) and number of fœtal placentæ (resorption of embryo or fœtus) were recorded.

TRANSPLANTATION OF FERTILIZED RABBIT OVA: THE EFFECT ON VIABILITY OF AGE, *in vitro* STORAGE PERIOD, AND STORAGE TEMPERATURE

Storage temperature (°C)	Storage time (hr.)	Age of ova before storage (days)	Number of: Ova transplanted	Recipient does	Does pregnant	Normal young	Young as percentage of ova transplanted
30	1–2	1	239	24	21	130	54
		3	132	11	5	41	31
		4	89	9	5	21	24
10	24	1	94	7	4	35	37
		3	103	7	6	38	37
		4	138	8	7	26	19
	96	1	182	14	9	28	15
		3	46	4	3	21	46
0	24	1	91	7	3	10	11
	96	1	146	9	4	9	6
38	24	1	137	13	8	28	20
	48	1	153	9	6	41	27

The results (see table) show: (1) that the younger the ova transplanted, the better is their chance of normal development. This is seen clearly in the case of ova freshly transplanted (1–2 hours storage time) and is also shown with ova stored 24 hours at 10° C. In the latter series the percentages of ova developing normally in the does actually pregnant were respectively 70, 44 and 22 with ova recovered at one, three and four days. The figures for ova kept 96 hours at 10° C. are not in agreement with this result; but the 46 per cent survival of the three-day ova is exceptionally high—perhaps because of the small number of cases.

(2) With storage at 0° C., normal development of one-day ova was very low after only 24 hours; but some young (6 per cent) were obtained after 96 hours storage. None of 59 three-day ova stored for 96 hours at 0° C., and transplanted among four does, developed into normal young. These results confirm that 10° C. is the optimal temperature for storage—as previously found[3] in a study on cleavage *in vitro*.

(3) When ova recovered at one day were cultured at 38° C. and then transplanted to the oviducts of does injected one day before operation, 20 per cent of those cultured 24 hours developed normally, and 27 per cent of those cultured 48 hours; but none of 109 ova cultured for 72 hours (six does) yielded normal young.

(4) The sex ratio of the young was not altered after storage *in vitro*; there is, therefore, no obvious differential mortality of the sexes at different storage temperatures. Of 429 young, only one, dead *in utero*, was abnormal, having a hernia and deformation of the fore limbs. It is probable that defective ova or embryos degenerated early. Because all non-pregnant animals were not sacrificed for examination, the recorded degeneration may be lower than its actual occurrence; several does were diagnosed as pregnant at two weeks but found to be not pregnant later, presumably owing to early degeneration of embryos.

Most of the ova that did not develop normally left no trace of having become implanted. Degeneration after implantation was more common with cultured or stored ova than after fresh transplantation. For does pregnant from freshly transplanted ova the mean litter size was 6·2, plus 0·58 degenerate. The corresponding figures for ova stored at 10° C. were 5·1 and 1·55, and for cultured ova 4·9 and 1·93.

(5) In the experiments previously mentioned, two-cell ova were transplanted to the oviduct; in other experiments (not shown in the table) they were freshly transplanted to the uterus. 92 one-day ova were divided among six does injected 72 hours before operation; none developed normally. 109 one-day ova were placed in the uteri of does 24 hours after injection; of the eight recipients one only became pregnant, the thirteen transplanted ova in this animal being represented at killing by a single normal fœtus, with no trace of other implantations. It seems that two-cell ova can survive *in vitro* at 0° C., 10° C. or 38° C., but fail to do so *in utero*.

(6) The following cases demonstrate the normal potentiality for development of large numbers of ova obtained by gonadotrophin injection; 53 two-cell ova from one doe, transplanted to four others, yielded 46 normal young. In another instance, 26 young were obtained from 35 two-cell ova divided among three recipients.

In conclusion, I wish to acknowledge my gratitude to Dr. Hudson Hoagland and Dr. Gregory Pincus for giving me the opportunity of working in their laboratory and especially to Dr. Pincus for advice. My thanks are also due to the Foundation for Applied Research, San Antonio, Texas, for a grant, and to Mr. Raymond A. Gunnarson for assistance.

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Hearing in Cetacea

DR. FRASER's remarks in *Nature* of November 29, 1947, p. 759, on sounds emitted by dolphins reached me by sea transport shortly after I had made the following observations which appear pertinent to his subject.

While examining male adults of the sperm whale (*Physeter catodon*) on board this factory, I have established that the external auditory meatus is a short blind sac which penetrates from the auditory aperture a distance no deeper than the blubber thickness, and which has altogether lost organic connexion with the middle ear. The sac has somewhat thickened unpigmented walls wherein muscular tissue may be developed: internally, these walls are thrown into transverse folds. On the other hand, the blue whale and the fin (*Balænoptera musculus* and *B. physalus*) retain the normal mammalian pattern, and in these whales one can trace, from external aperture to tympano-petrosal bone, a continuous meatus the thin smooth epidermal lining of which is pigmented

for the greater part of its length. Their Eustachian tube also presents no unusual features, but I have not so far been able to examine it in the sperm.

Obliteration of the meatal lumen in sperm whales must occur somewhere in the middle region of the canal, since dissection with steam-saw and axe reveals that the proximal portion, running in the temporal bone, is still intact. Also, in two physically immature adults examined, the external meatus, after termination of its cavity, was prolonged into a short solid stalk representing the canal after obliteration of its lumen. This suggests that the fœtal condition may exhibit a continuous meatus, but unfortunately sperm fœtuses are not available in the Antarctic.

There is evidence that the sperm whale dives to great depths, and it is apparent that permanent closure of the external auditory meatus has adaptive advantage in this cetacean, which must be capable of tolerating considerable changes in hydrostatic pressure.

The adult sperm whale can thus only hear by penetration of vibrations through the solid tissues of the head. In a mammal this does not appear an efficient path ; but in the light of Dr. Fraser's remarks on the sensitivity of dolphins to supersonic emissions, it seems clear that such vibrations of high frequency and short wave-length would suffer considerably less absorption, during direct transmission through the sperm head, than sounds within the auditory range.

The experience of whaling gunners in catchers fitted with 'Asdic' gear shows that the larger rorquals, as well as dolphins, are, in fact, sensitive to supersonic vibrations. The 'ping' not only locates but also frightens the whale, which makes off at speed. This becomes an advantage should the catcher be fast enough to overtake its quarry, because when blue and fin whales are running they blow more often and are therefore more easily followed ; moreover, they are sooner exhausted. The deliberate working of the 'Asdic' at 'short-interval transmission' to keep whales on the run has, in fact, been employed successfully in chasing.

I am indebted to both Messrs. Chr. Salvesen and Co. and to the Discovery Investigations for facilities enjoyed in the south.

ROBERT CLARKE

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A Plant Disease Caused by a Spore-forming Bacterium under Natural Conditions

THAT spore-forming bacteria, that is, species of the genus *Bacillus*, are responsible for some plant diseases has been recorded from time to time, but has rarely been confirmed ; it is not yet generally accepted, as the great majority of bacterial plant diseases are known to be due to bacteria which do not form spores.

A few years ago, one of us (W. J. D.) recorded[1] the complete disintegration, under laboratory conditions, of the parenchyma of whole, or slices, of potato tubers, carrots, onions, cucumbers and iris stems by *Bacillus polymyxa* (Prazmowski) Migula, a soil-inhabiting organism. Madhok and Fazal-ud-Din[2] investigated a disease of tomato fruits which was also shown to be due to a species of *Bacillus* which

Fig. 1 Fig. 2

Fig. 1. ORIGINAL FRUITS BROUGHT FROM THE SOUTH OF PALESTINE.
Fig. 2. INFECTION EXPERIMENT ON GREEN PEPPER FRUITS WITH THE ORGANISM ISOLATED FROM MATERIAL FROM THE SOUTH OF PALESTINE

they named *B. fructodestruens*, and the subject was further reviewed a few years later[3].

Quite recently, one of us (Z. V.) has investigated a widespread fruit-spot of green pepper (*Capsicum annuum*) in Palestine, which was shown to be caused by a spore-forming bacterium identified at Cambridge as *B. polymyxa*. On the maturing fruits spots developed, one to five in number, light brown to grey, soft or firm, varying in size from 8 mm. to 12 mm. (Fig. 1). Microscopic examination of the softened tissues underlying the spots revealed the presence of numerous rod-shaped bacteria which were isolated in pure culture and produced subterminal spores. 48-Hour broth cultures were pasteurized at 85–90° C. for 10 min. and were used to establish cultures on potato dextrose agar from which suspensions in water were used for a series of infection experiments. Drops of the suspension were deposited on the surface of *Capsicum* fruits, which were then wounded by needle pricks. The inoculated fruits, placed under bell-jars over water, at room temperature (28–30° C.), developed lesions similar to those observed in the field (Fig. 2).

The organism was re-isolated from these spots, and the infection experiments were repeated with the re-isolated organism with like results. Controls pricked through drops of sterile distilled water did not develop any sort of infection. Various vegetables inoculated with the organism, under laboratory conditions, developed a typical soft rot of the parenchyma ; but no infection of *Capsicum* was obtained either by spraying on a suspension of the bacteria or by inoculating wounds on *leaves*. This last observation is in agreement with that made at Cambridge with another strain of *B. polymyxa*, used to inoculate *stems* of iris and tomato plants which did not become infected, although kept under moist conditions and at a relatively high temperature.

It appears, therefore, that under *natural* conditions, involving high humidity and a relatively high (28–30° C.) temperature, the spore-former, *Bacillus polymyxa*, is a wound parasite, able to disintegrate the parenchyma of *Capsicum* fruits by means of its pectic enzymes.

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B_T, A NEW VITAMIN OF THE B-GROUP AND ITS RELATION TO THE FOLIC ACID GROUP, AND OTHER ANTI-ANÆMIA FACTORS

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THE mealworm, *Tenebrio molitor*, has recently been shown to be a very suitable test subject for folic acid and certain other, still unidentified B-factors. When grown on an artificial diet consisting of casein (20 parts), glucose (80 parts), water-insoluble fraction from yeast (2·5 parts), cholesterol (1 part), a salt mixture (2 parts), and aneurin, riboflavin, nicotinic acid, pyridoxin, pantothenic acid, choline chloride and inositol in ample amounts, at least two more factors are essential for growth and survival, folic acid and a factor contained in a norite filtrate from yeast or liver extract[1,2]. In view of the present interest in the folic acid group and its relation to anti-anæmia principles, our recent results on the mealworm may be of general interest. Throughout this report the term folic acid has been used to denote pteroylglutamic acid.

TABLE 1. THE EFFECT OF PTEROYLGLUTAMIC ACID, YEAST CHARCOAL FILTRATE, LIVER CHARCOAL FILTRATE AND PARENTERAL LIVER EXTRACTS ON GROWTH AND SURVIVAL OF *Tenebrio molitor*. NOS. ALIVE (OUT OF 20) AND AVERAGE WEIGHTS AFTER 10 WEEKS AT 25° C.

Addition to basic diet: Pteroylglutamic acid	Source of B_T	No.	Average weight (mgm.)
Absent	absent	all dead	—
Present	absent	all dead	—
Present	1% yeast	17	55
Absent	liver charcoal filtrate	10	12
Present	liver charcoal filtrate	17	48
Absent	yeast charcoal filtrate	9	10
Present	yeast charcoal filtrate	20	42
Absent, in its place parenteral liver extract			
Lederle 0·6 %	liver charcoal filtrate	14	13·1
'Examen' 0·6 %	liver charcoal filtrate	10	9·5

The relations of folic acid and the above-mentioned norite filtrate factor are shown in Table 1: in the absence of both factors growth is very slow and the mortality high. Addition of a charcoal filtrate from liver or yeast extract has always the effect of increasing length of life, without noticeably improving rate of growth. Folic acid alone sometimes to some extent accelerates rate of growth; but death usually occurs even more rapidly than on diets without folic acid. Only in the presence of both factors do growth and survival become normal, as compared with the effect of 1 per cent yeast (Table 1). For the sake of convenience we have tentatively named the norite filtrate factor 'vitamin B_T' (to indicate its activity on *Tenebrio*). *Tenebrio*, therefore, is an admirable subject for testing the activity of any substance in regard to its possible relation to folic acid or B_T; thus we can investigate the relationships of a number of substances which have come to light in connexion with and since the discovery of folic acid.

Pteroylglutamic Acid and Pteroylheptaglutamic Acid

It is now known that pteroylglutamic acid occurs in natural food substances largely in the form of 'conjugates' with glutamic acid. Of these, pteroylheptaglutamic acid, which had formerly been called vitamin B_c conjugate, was isolated from yeast. Recent reports emphasized that pernicious anæmia patients in contrast to normal subjects fail to utilize the conjugate as folic acid[3]. *Tenebrio*, similarly to the chick[4] and certain micro-organisms, utilizes pteroylheptaglutamic acid very well. Shortage of material restricted us to two series of tests which agreed in general trend, but not in detail (Table 2). In the first the minimum optimal dose was 0·5 μgm./gm. of the dry food with folic acid and 2·5 μgm./gm. with the conjugate, while in the second 0·12 μgm./gm. folic acid showed already an optimal effect, which only appeared with 10–20 times larger doses of the conjugate. However, in the latter case 0·12 and 0·25 μgm./gm. of the conjugate had already a marked effect.

TABLE 2. THE EFFECT OF PTEROYLGLUTAMIC ACID AND PTEROYLHEPTAGLUTAMIC ACID IN THE PRESENCE OF LIVER CHARCOAL FILTRATE ON GROWTH AND SURVIVAL OF *Tenebrio molitor*. NOS. ALIVE (OUT OF 20) AND AVERAGE WEIGHT OF LARVÆ AFTER 10 WEEKS

Experiment 367	Pteroylglutamic acid		Pteroylheptaglutamic acid	
Dosage (μgm/gm.)	No.	Av. weight mgm.	No.	Av. weight mgm.
0	3	10·6	3	10·6
0·1	12	23·3	9	17
0·5	16	51·2	16	39·8
2·5	18	54·8	15	50
10·0			18	52
Experiment 372				
0	17	14·5	17	14·5
0·125	18	53·5	18	23·3
0·25	20	53·5	19	28·1
0·5	20	47·2	20	38·7
1·0	18	59·7	19	42·2
2·0	18	51	18	50
4·0			20	53·5

These results, though rather incomplete, suggest that on a molecular basis the efficiency of pteroylglutamic acid and pteroylheptaglutamic acid cannot be very different.

There remained the possibility that pteroylheptaglutamic acid, which is the natural form in yeast, might have B_T activity as well as folic acid activity. This proved not to be the case; even very large quantities failed to give a survival effect in a diet which contained no source of B_T.

Pteroylglutamic Acid, B_T and Anti-anæmia Liver Extracts

After the activity of folic acid in the remission of pernicious anæmia had been discovered, it came as a surprise when statements appeared to the effect that purified parenteral anti-pernicious anæmia liver extracts did not contain significant amounts of folic acid[5] or of the conjugate[6]. These results have been fully confirmed in tests with *Tenebrio*. Two well-known commercial parenteral liver extracts were tested, one from Lederle Laboratories, Inc. (15 U.S.P. per ml.), and the other 'Examen' (Glaxo Laboratories). Neither of these preparations showed the slightest folic acid activity, as affecting the growth-rate, when tested in the presence of an effective supply of B_T in the form of a liver charcoal filtrate (Table 1).

Next the question arose as to the possible B_T effects of these parenteral liver extracts. Consequently a series of tests was set up in which folic acid was supplied as pteroylglutamic acid, and the effects of parenteral liver extracts compared in a series of concentration with that of a standard liver charcoal filtrate. No effect was recorded with 'Examen' in any of the concentrations used, while the Lederle extract gave a positive effect in

TABLE 3. COMPARISON OF THE EFFECTS OF YEAST, A LIVER CHARCOAL FILTRATE AND TWO PARENTERAL LIVER EXTRACTS AS SOURCES OF B_T. ALL DIETS CONTAIN 4 μGM./GM. PTEROYLGLUTAMIC ACID. NOS. ALIVE (OUT OF 20) AND AVERAGE WEIGHTS AFTER 10 WEEKS

Addition to diet	No.	Average weight (mgm.)
None	all dead	—
1% yeast	20	45·5
Liver charcoal filtrate, 0·6%	19	45
Parenteral liver extract		
Lederle, 0·075%	1	8
0·22%	3	13·3
0·66%	7	34·5
2·0%	15	39
'Examen' 0·075%	all dead	—
0·15%	all dead	—
0·3%	1	21
0·6%	1	13

a very large dose only (Table 3). It is somewhat difficult to compare the activity of liver preparations from different sources, even if the corresponding amounts of fresh liver from which they are derived are stated on the labels, as the total losses during preparation are unknown. The dry weights of the three preparations in question, and their fresh liver equivalents, were as follow :

	mgm./ml.	Liver equivalent
Liver charcoal filtrate	293	1 ml. ≡ 6 gm.
'Examen'	10	1 ml. ≡ 50 gm.
Lederle	140	1 ml. ≡ 100 gm.

The amounts in which these extracts were used in the diets are stated in Tables 1 and 3 as the percentages of the three solutions mentioned above added to the dry diet. For example, 0·6 per cent of an extract means that 0·006 ml. of it has been added to 1 gm. of the dry diet. It can then be immediately seen that the B_T activity of the liver charcoal filtrate is vastly greater than that of the 'Examen' or Lederle extract which derived from eight to sixteen times respectively larger amounts of liver. Similarly, 0·15 gm. of folic acid per gm. of the dry diet produced a good growth effect in *Tenebrio*. On the assumption that 1,000 lb. of fresh liver contains 1·5 gm. of folic acid[7], it follows that 1 gm. of fresh liver might contain 3·3 μgm. of folic acid, and an optimal effect should be induced with 0·05 gm. of fresh liver/gm. of the diet, that is, 5 per cent. On this reckoning, 'Examen' and the Lederle extract should have been equivalent to 5 per cent fresh liver in amounts of 0·1 and 0·05 per cent of the diet, while in fact they showed no effect in amounts of 0·6 per cent. Even allowing for the loss of appreciable amounts of active substances in such preparations, it remains obvious that the kind of activity for the purpose of which the anti-anæmia concentrates have been developed must by necessity be entirely different from that of folic acid or B_T.

It is interesting to record that similar results, stating the virtual absence of folic acid in six liver preparations of established clinical potency, have just been reported in tests which involved the use of another insect, the larva of a mosquito (*Aedes ægypti*). Here no relation could be found between folic acid activity, measured by the level of pupation response, and anti-anæmia activity[8].

Nature of B_T

The need for B_T by *Tenebrio* was originally discovered when, several years ago, attempts to grow *Tenebrio* on artificial diets had failed and a search was made into the nature of missing factors in diets for *Tenebrio* and other insects[1,2]. At that time the chief criterion for 'folic acid', as it was understood then, was adsorption on charcoal at an acid *p*H. It then became clear that *Tenebrio*, in addition to folic acid, required a liver or yeast fraction from which folic acid had been effectively removed by charcoal. It is, however, by no means certain that B_T remains quantitatively in the charcoal filtrate. In the course of our work, some loss of activity of filtrates, after treatment with charcoal, has sometimes been observed, up to about one third, though in most cases these losses were considerably smaller. This is important to keep in mind when comparing the properties of B_T with those of other unidentified B factors which have been reported from other laboratories. The existence of such factors adsorbable by charcoal but elutable with difficulty have, for example, been reported by Jaffé and Elvehjem[9] for the rat. A closer relation seems so far to exist in a guinea pig factor (*GPF* 3), described by Woolley and Sprince[10]. *GPF* 3 was not noticeably adsorbed on charcoal at *p*H 3·4, was not precipitated by lead acetate and was relatively stable to alkali. These properties seem to apply fully to B_T. A liver charcoal filtrate, which was treated with lead acetate, failed to show any loss in B_T activity.

Work undertaken at Cornell University with chicks[11] had revealed the presence in brewers' yeast of two essential nutritional factors which were termed *S* and *R*. These factors were afterwards shown to be separable by a simple charcoal treatment at *p*H 3·0 when *R* was adsorbed and *S* remained in the filtrate[12]. *R* was later found to be a folic acid conjugate[13]. So far the resemblance between B_T and *S* is very close. Recently, however, the Cornell workers[14] report the probable identity of factor *S* with strepogenin, a compound of polypeptide nature required by various micro-organisms. From our knowledge of the nature of B_T the possibility of its identity with strepogenin seems very remote, especially as our *Tenebrio* diet contains 20 per cent of casein, which is a very good source of strepogenin. In anticipation of facts to be discussed below, it is, however, relevant to record that chicks, on a factor *S*-deficient diet, fail to grow, become anæmic, show a generally weakened condition and usually die before they are eight weeks old.

Reports of additional unknown factors from yeast or liver, which are of importance for *Streptococcus fæcalis*[15], a monkey[16] and the chick[17,18] are not specific enough to allow comparison with B_T. B_T shows some features of the active principle in crude yeast or liver preparations, found by Wills to be effective in certain cases of nutritional anæmia which do not respond to parenteral liver extracts. The active principle of Wills's factor is not adsorbed on charcoal, and what has been so far published about its properties[19] shows a close resemblance to B_T.

It has been claimed in work with chicks, by Cornell workers, that for optimal effects of folic acid or 'conjugates' the addition of 4-pyridoxic acid lactone was required[20]. These reports made it possible that 4-pyridoxic acid might have B_T activity. 4-Pyridoxic acid in a wide range of concentrations was therefore added to purified diets which contained folic acid, but failed to reveal any B_T activity. The results of the Cornell group were not confirmed by two other groups of workers[4,21,22].

Attempts to isolate B_T from yeast and other natural products have been proceeding for some time in this Department, with the co-operation of Dr. A. H. Cook, of the Organic Chemistry Department of this College. The most active preparation so far obtained showed more than a hundred-fold concentra-

tion of B_T, and good responses have been recorded with quantities of roughly 3 μgm./gm. of the dry diet. By analogy with the activities of many of the known B-vitamins, it is reckoned that such concentrates may possibly contain 10–50 per cent of B_T.

Conclusions

The common mealworm, *Tenebrio*, has been shown to react very sensitively to the absence of folic acid and another, still unidentified, B-factor (B_T). This makes it an admirable subject for studying the folic acid or B_T activity of any known or unknown compound. There is reason to suspect that B_T may have some relation to the Wills's factor, and its similarity to factor *S* of the Cornell workers again points to a possible anti-anæmia effect. This would make *Tenebrio* an important tool in the study of anæmia, where the absence of a convenient testing organism has always hampered progress. But even if relations between B_T and anti-anæmia activity proved unfounded, a study of unknown B factors which have come to light in work with *Tenebrio* and other insects might still prove in the end to have a significance far beyond this class of animals. It has been shown again and again that the B-vitamins have all-important functions in the metabolism of all forms of life, from bacteria to man, and there has scarcely been a case of a new B-factor which was not ultimately proved to be of general significance. It is therefore perhaps not too much to hope that a further study of the nature and action of new B-factors in insects might, in the end, lead to the discovery of new principles of importance both in biology and medicine.

I wish to record my thanks to the Medical Research Council for a grant which made this work possible. Further, I wish to thank Lederle Laboratories, Inc., for pteroylglutamic acid and parenteral liver extract; Parke Davis and Co. for pteroylheptaglutamic acid (B_c conjugate); Merck and Co., Inc., for 4-pyridoxic acid; and Glaxo Laboratories for liver extracts.

Summary

The mealworm, *Tenebrio molitor*, requires for normal growth and survival, in addition to at least eight of the known B-vitamins, also folic acid and a new factor which has been tentatively named B_T. Folic acid conjugate can be utilized in the place of folic acid, but has no B_T activity. Concentrated parenteral anti-anæmia liver preparations do not contain significant amounts of either folic acid or B_T. The possible relation of B_T to other missing B-factors, reported from other laboratories, and to Wills's anti-anæmia factor is discussed.

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AGRO-CLIMATIC ANALOGUES

By G. MELVYN HOWE

Commonwealth Bureau of Pastures and Field Crops, Aberystwyth

THE majority of the cultivated plants of the eastern and western hemispheres are represented by totally different genera, and until comparatively modern times very few such plants were common to both hemispheres. Many of the cereal and legume crops cultivated in the Old World before the time of Columbus were quite unknown in America, and the reverse was equally true. The subsequent introduction of rubber into the Far East from the Amazon region, via Kew, is the classic example of plant introduction; but of equal importance we may note that of sugar cane from the East into the West Indies, potatoes from South America into Europe, cinchona from South America into the East Indies, groundnuts from Brazil into Africa and India, and in more recent years, soybeans from Manchuria into America and parts of Europe.

The Second World War witnessed, and to a certain extent was the cause of, increased numbers of plant introductions. This was especially so in the case of America, where numerous new plants were introduced in an attempt to overcome war-time shortages of various plant products. But it is with the urgent necessity of speedy rehabilitation of the many war-devastated agricultural areas at the present time that plant introduction assumes its greatest importance.

To facilitate agricultural rehabilitation the American Institute of Crop Ecology is at present engaged in publishing an International Agro-Climatological Series[1] which comprises studies dealing with North American agro-climatic analogues for the various countries of the world. Seven studies have already been published; another fifteen are in course of preparation. The objective of each study is "to organise, define, and analyse the various distinct agro-climatic conditions prevailing in the different parts" of the country under review and to compare them with the various agro-climatic regions of North America so as to determine "climatic analogues". Climatic analogues are defined as "areas that are enough alike with respect to some of the major weather characteristics affecting crop production, particularly during the growing period, to offer a fair chance for the success of plant material transplanted from one area to its climatic counterpart".

Each study gives a general and comparative geography of the country concerned and a brief account of its climate. Certain of the studies contain

additional sections, as, for example, the one for the Ukraine, which also contains an account of the natural agricultural belts of the country and the major plant species of each, and the Albanian study, which gives an account of the natural vegetation, crop geography and agricultural practices of that country.

The source of the material for the main section of each study is the climatological data from the various meteorological stations of North America. The elements of comparison—monthly and yearly temperatures, maximum and minimum temperatures, average monthly, seasonal and yearly precipitation, precipitation-effectivity indices and ratios (Thornthwaite's method), length of frostless periods, and latitudes—are studied for a particular meteorological station and a search is then made among the North American stations for a "similar climatic and latitudinal environment". The North American environment when found is then noted as being climatically analogous to it. Relief maps of the country are presented to show the location of the various meteorological stations, and the names of States and regions of their North American climatic counterparts are given in each case, if such counterparts exist. Agro-climatic charts give full meteorological data for each observing station within the country studied and the North American climatic parallel of each.

This agro-climatological series by M. Y. Nuttonson, the background for which was developed by experiences gathered in non-emergency plant introductions where careful varietal field trials of introduced plant material were possible, will be welcomed by all plant exploration and introduction organisations, ecologists, agro-climatologists and geographers. Until such time as meteorological recording instruments are developed to give readings more in keeping with the requirements of agro-climatologists and such factors as evapo-transpiration and potential evapo-transpiration[2] are taken into account in the formulation of more detailed world homoclimes and agro-climatic analogues, they will serve as an excellent basis to all plant introduction work. It is to be hoped, however, that an institute similar to the American Institute of Crop Ecology will be set up in Britain to determine world homoclimes and agro-climatic analogues for the British Commonwealth. The Commonwealth Bureau of Pastures and Field Crops would appear to be the obvious centre for this work. Studies dealing with British Commonwealth agro-climatic analogues for the various countries of the world might well be initiated at this information Bureau. It would also serve as a pool for receiving suggestions from agriculturists and meteorologists concerning new types of meteorological instruments that should be evolved (for example, one for measuring water movement from the earth to the atmosphere) to meet the needs of the modern agro-climatologist and agriculturist generally.

Agricultural expansion in the British Commonwealth will most surely require, among other things, the introduction of new plant material into undeveloped or partly developed areas. Many of these areas will greatly benefit from new pasture plants, new legumes, etc., which might be obtained as a result of plant explorations in countries having similar homoclimes. For example, there is a proposal to send an Australian expedition to homoclimal areas in South America to study the more promising wild and cultivated plants with the view of transferring some to Australia. South America's richness in useful plant species is considered a valuable source for plant introductions for northern semi-tropical portions of Australia. Similarly it is proposed to send an expedition to Indo-China and Siam with the object of seeking and securing types of the banana family for use on the breeding work in the West Indies.

A series of studies such as have been suggested, dealing with British Commonwealth agro-climatic analogues for the various countries of the world, would undoubtedly facilitate plant introduction, adaptation and exploration work, and serve as a useful complement to the studies at present being carried out in the United States.

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SOUTH AFRICAN MUSEUMS ASSOCIATION

ANNUAL GENERAL MEETING

THE twelfth annual general meeting of the South African Museums Association was held in the Africana Museum (Public Library building), Johannesburg, during March 16–19. The Mayor of Johannesburg, Mr. G. B. Gordon, opened the meeting on a particularly happy note by remarking on the Johannesburg City Council's appreciation of the value of museums and art galleries in the preservation of objects of art, science and history, and stating that education departments in various parts of the Union had already recognized their importance in adult and juvenile education. In the course of his address, Mr. Gordon also referred to his Council's pledge to establish, in collaboration with the University of the Witwatersrand, a museum of science and industry, and to its promise to provide a site for the South African National War Museum (at present housed in two Bellman hangars in a portion of the Zoological Gardens). By 1952, furthermore, he hoped that a new building to house the Africana Museum would be erected. From this, therefore, it would seem that Johannesburg can look forward to cultural developments with optimism.

Following the Mayor, Mr. R. F. Kennedy, retiring president of the South African Museums Association, presented his report for 1947. This made it clear that South African museums suffer as much from inadequate financial support as do a large number of the museums in Britain. Mr. Kennedy stated that though applications for increases in grants for museums had been made both to the Union Government and to provincial councils, there had been little or no response. (In spite of a steady rise in costs, grants for museums in South Africa have not altered materially since 1938.) In the case of the State-aided institutions, the Minister of the Interior had promised the formation of a special committee to study their particular needs; but no action, apparently, had actually been undertaken in this direction. Since, however, the State-aided museums now come under the Ministry of Education, there is hope that their problems will receive the attention due to them.

In his presidential address, Mr. Kennedy saw in 1948 the beginning of "a considerable development in museum work in South Africa", but he reminded

delegates that the advancement looked for would depend not so much upon Government, provincial and local taxation as upon the museums themselves. "If the museums," he said, "can show that they have a rational plan, the support of the public through their representatives will be forthcoming." In this Mr. Kennedy spoke candidly and with truth, for in most South African museums at the present time there is much room for improved and more up-to-date methods of exhibition, and for the better presentation and co-ordination of the subjects with which they deal. Educational services for the general public, also, are far behind those rendered by some European and most American museums.

An important outcome of the Johannesburg conference was the formation of a special committee (to be known as the South African Museums Association Research Committee), to deal with all matters relating to research carried out by museums and allied institutions in the Union. South African museums have long been noteworthy for the amount and quality of the research they carry out in various fields; but it is now felt that there is need for the proper co-ordination of this work. This Committee, therefore, will henceforward act as the co-ordinating body. Its principal functions will be: (1) to advise Government and other authorities in matters concerning museum research; (2) to consider applications made by museums for grants, and to forward such applications with recommendations to the appropriate authority; and (3) to prepare a survey of the research already being carried out by these institutions with the object of co-ordinating this branch of museum work. Function (2), moreover, means that in future all applications from museums for research grants will automatically pass through the Research Committee for first consideration. The co-option on the same Committee of representatives of the South African Council of Scientific and Industrial Research, and of the South African Council for Educational, Sociological and Humanistic Research (constituted in 1946 by the Minister of Education to promote research in the humanistic fields), is a probability.

Another special committee which was formed at this year's meeting will press forward matters relating to increased Government support for South African museums and art galleries. It was decided, also, that a deputation from the Museums Association should ask the Transvaal Director of Education to urge the appointment of guide-lecturers for the instruction of school classes visiting Transvaal museums. The Transvaal Provincial Museum at Pretoria will send an independent deputation upon the same subject, and by now the City Council of Johannesburg will have been asked to act likewise.

The proceedings of this year's South African Museums Association conference, therefore, have made it clear that museum officials, and others interested in the work of museums, recognize the need for improvement in the Union's museum services; and from the strenuousness of discussion and the resolution which marked the whole of the meeting, there is every indication that the improvement looked for will come through equally strenuous action. One of the first necessary steps, however, will lie in an increase of staff trained in modern museum methods and technique.

Prof. R. H. Compton was elected president of the South African Museums Association for the coming year, and Mr. E. C. Chubb was re-elected secretary. In recognition of his long and valued service to the Association, Mr. Chubb was also elected an honorary life member.

During the conference, the Abbé Breuil, assisted by Miss Boyle, addressed the members on the Makhetha rock-shelter paintings of Basutoland and the Brandenberg rock-paintings of the Tsisab Ravine in South-west Africa; his very fine coloured drawings of these paintings decorated the walls of the conference room.

Members of the Association and visitors attended a reception in the Town Hall on the opening day of the conference, and on subsequent days visits were arranged to the University of the Witwatersrand, the Art Gallery, the South African National War Museum and the Union Astronomical Observatory.

A feature of the Johannesburg meeting was a special exhibition depicting the work, aims and needs of South African museums and art galleries. Coloured posters executed by the staff of the Africana Museum, and sets of photographs sent by individual museums and art galleries formed an attractive and informative introduction to this subject. The exhibit is available for the use of other South African museums. Its publicity value is high, and it is to be hoped that it will find its way to all museum centres in the Union. It was a pity that this exhibition did not get the press notice it deserved while it was in Johannesburg.

J. R. HARDING

THE IMPERIAL INSTITUTE

THE annual report of the Imperial Institute, South Kensington, London, for 1947 shows that an unusually large number of economic inquiries and laboratory tests have been made at the Institute for Empire Governments, industrial research organisations and commercial firms in search of new sources of raw materials. In the Plant and Animal Products Department alone, 203 samples were examined and 824 inquiries handled. Three scientific papers were published by the Department recording research work on methods of pyrethrum analysis carried out in collaboration with other authorities. The consultative committees on vegetable fibres, on gums and resins, on hides, skins and tanning materials and on insecticide materials of vegetable origin all met again once during the year, and matters which received attention included manila hemp, the utilization of linseed straw, the possibility of increasing production of rosin, and the insecticidal properties of *Cymbopogon giganteus* and *Neorautenania ficifolia*, from Northern Rhodesia. *Barataballi* latex, from British Guiana, has yielded a coagulum of some promise as an ingredient of the base for chewing sweets. Trials with new insecticides as preventives against hide beetle have been completed, and a report is being prepared. The Consultative Committee on Silk has submitted to the Secretary of State for the Colonies a statement on the need for a programme of sericultural experiments in the Colonial Empire, and has also prepared for the High Commissioner for Southern Rhodesia a report on the nature and scope of such experiments that might be undertaken in Southern Rhodesia.

Investigations reported during the year dealt with wattle bark from Jamaica, cutch from Burma, *Melaleuca bracteata* oil from Kenya, a possible source of methyleugenol, citrus oils from Palestine, shark liver oils from Trinidad, tung oil from Nyasaland,

soya beans from Nigeria and tobacco from Cyprus. Of the 824 inquiries, the report mentions particularly those relating to lemon juice and peel, papain, jute and jute substitutes, cellulose for wood and rayon pulp and short-length piassava from Sierra Leone.

The Intelligence Section of the Mineral Resources Department dealt with 1,048 inquiries, and among these vermiculite continued to figure, while other inquiries related to supplies of beryl, zinc deposits in Burma, Empire resources of sillimanite minerals, Indian and Australian pyrophyllite, barytes for oil-well drilling muds, and clays for bases in soap substitutes. Staff limitations have prevented resumption of the preparation of revised editions of the series of mineral monographs, but the mineral resources section of the quarterly *Bulletin* of the Institute has continued, and results of the investigations on samples of coal from Tanganyika were published as an appendix to an article in the *Bulletin* on the geology of the Namwele-Mkomolo Coalfield by R. B. McConnell. Among the investigations carried out during the year may be recorded those on bleaching earth from Cyprus, lignite from Sierra Leone, manganese ore from Dominica, and clays, coral, volcanic materials and sands from St. Vincent as possible building materials.

The Rubber Department gave its chief attention during the year to a continued study of the resilience of rubber, and improvement in resilience of *Hevea* rubber by thorough purification previously reported has been confirmed. The vulcanizing and mechanical properties of the highly purified rubber have been studied in some detail, as well as the effect of treating the latex with substances likely to affect molecular cohesions and linkages. Attempts have also been made to determine the association of phosphorus with the rubber particles in preserved latex.

The report also includes an account of the educational work of the Institute, both its publications and exhibitions, the Central Film Library, the Empire Lantern Slide and the Film Strip Library and the general library, to which more than 5,700 books, official reports and pamphlets were added in 1947, in addition to the 800 periodicals normally received.

THE FISHERIES SCHOOL AT CRONULLA, NEW SOUTH WALES

ONE of the most interesting and informative technical publications issued in connexion with any fishing industry is the *Australian Fisheries Newsletter* published by the Commonwealth Fisheries Office. This first-rate monthly never fails to provide a wealth of accurate and helpful information covering all aspects of Australian fishing activities together with a useful leavening of articles and news items dealing with the more general aspects of marine biology and its bearing on fisheries problems in all parts of the world. Of particular interest has been a series of articles* on the foundation and development of a fisheries training school on a site adjoining the Marine Biological Laboratory of the Australian Council of Scientific and Industrial Research in New South Wales.

* *Fisheries Newsletter*, **5**, No. 2, 3 (April 1946); **6**, No. 1, 3 (Feb. 1947); **6**, No. 2, 8 (April 1947); **6**, No. 5, 3 (Oct. 1947). Published by the Commonwealth Fisheries Office, Dept. of Commerce and Agriculture, at the Publicity Press (1938) Pty., Ltd., 71–75 Regent Street, Sydney.

The Australian fishing industry at the present time employs some ten thousand persons in actual fishing. No accurate figures are available concerning the number of persons engaged in ancillary occupations. Very rapid developments were made during the Second World War, and since the conclusion of hostilities there has been a heavy influx of new personnel. Many of those have come from families already in the industry; but there is also a steady recruitment of ex-Service men without previous experience of any branch of fishing activity. In order to ensure that those men shall have the best possible chance of making good in their new occupation a Commonwealth Fisheries School has been established at Cronulla, New South Wales, well equipped and adequately staffed for the work it sets out to do.

A technical supervisor is responsible for technical training. He is assisted by an assistant technical supervisor, and the masters and crews of the school's instructional vessels, which comprise a 75-ft. diesel trawler, a 66-ft. Danish seiner, a 25-ft. inshore motor fishing vessel and several smaller boats.

The more theoretical side of the instruction is given by officers of the Fisheries Division and the Division of Food Preservation and Transport of the Council of Scientific and Industrial Research, the staff of the Sydney Technical College, and members of the Commonwealth Fisheries Office.

The trainees reside on the premises, so a camp superintendent is in charge of the school buildings, assisted by a quartermaster, cooks and camp attendants. There are thirty bedrooms, each accommodating two persons, and a 'loughboy' for storing clothes and other personal gear. Adequate bathing facilities and a laundry are also available. The large messroom can accommodate seventy persons, and the catering staff, operating an all-electric kitchen, provide a good service of both hot and cold meals.

Approved applicants accepted for full-time training pay no fees for the course. Where necessary, an allowance is made for books, tools and other essentials, and, in addition, a living allowance of £3 5*s*. a week is paid to those without dependants. To a trainee with dependants an additional sum up to a maximum of £2 a week may be paid, according to the number of dependants and their degree of dependency.

The course at Cronulla was originally planned to extend over four months, after which the trainees were required to go into subsidized employment in the fishing industry in order to obtain further intimate experience of practical work. Difficulty has been experienced, however, in placing the trainees in subsidized jobs because fishing in Australia is mostly operated by one-man boat-owners, by crews who are joint owners of their own boat, and by owners with crews on a share basis. It has therefore been decided that the training course shall be extended from four months to thirty weeks and that the period of subsidized employment be abolished. It is thought that the longer course will provide sufficient practical experience in the fishery school's own vessels to enable its students to stand at once on their own feet in the fishing industry. To assist in achieving this objective some of the theoretical instruction given during the first course will be reduced and more time given to practical work both at sea and on shore. For the first twenty weeks all trainees will take the general fisheries syllabus, after which they will specialize in that branch of the industry w..ich they intend to enter.

It is felt in some quarters that a school of fishing should be established in Great Britain, particularly for the training of fishery officers and others who will be going out to British Colonies under the Colonial Development Scheme. It is doubtful whether there would be enough trainees derived from this source to support a satisfactory school on a permanent basis. But the British fishing industry also would benefit if the recruits to its ranks could have a period of training in a well-planned and wisely conducted school of fisheries such as that at Cronulla. Fishing in Britain and other European countries has long ceased to be run on primitive 'rule-of-thumb' lines, and there seems at present to be a decided danger that British fishermen may be outstripped by Continental rivals who give more attention to the proper study of fishing in all its aspects. G. A. STEVEN

BOTTOM DEPOSITS OF LAKE WINDERMERE IN RELATION TO THE QUATERNARY HISTORY OF THE BRITISH ISLES

THE importance of the bottom deposits of Lake Windermere as a source of information concerning the post-glacial history of north-western England has already been indicated by the stratigraphy and diatom sequence established by Winifred Pennington (Mrs. T. G. Tutin) (*New Phytol.*, **42**, 1; 1943). These deep-water deposits (brought within reach by the unique qualities of the Jenkin core-sampler) have been used again by the same worker to extend our knowledge into the late-glacial period (*Phil. Trans. Roy. Soc.*, B, **233**, 137; 1947). Water-laid, laminated clays are found above and below a layer of grey detritus silt which contains remains indicating that it was laid down during a cool-temperate phase. This is tentatively correlated with the Allerød oscillation established in north-western Europe and Ireland.

Analysis of the post-glacial layers (utilizing both pollen and macroscopical plant remains) reveals a fairly close correlation with events in East Anglia, except in the later stages where a *Salix* maximum occurs in Zone IV and *Betula* assumes, in Zone V and early Zone VI, the dominance characteristic of profiles from the west of Britain. *Tilia* does not appear until Zone VII, and *Fagus* and *Carpinus* are completely absent. *Pinus*, which appears to be consistently over-represented in the deep-water deposits, falls off very rapidly at the transition between Zones VIc and VII, but always reappears at a characteristic position near the surface, where the brown and indurated clay gives way to soft, black, rather unconsolidated gyttja. This reappearance may be due to planting (a rise in the importance of grass pollen in deposits laid down 2,000–2,500 years ago having already suggested the beginning of clearance of the primeval forests).

Samples from beneath shallow water provided the clearest pictures of the late-glacial and early post-glacial changes, but deposition appears to have ceased (due to turbulence) when the mud has approached to within about three metres of the water-surface. The lesser clarity of the early stages of deep-water samples appears to be due to a very slow deposition here.

Possible correlations of dating with geological reports for north-western England, Ireland and Scandinavia are clearly shown in tabular form, and it is concluded that the lower laminated clay is contemporaneous with the Scottish re-advance, the Carlingford re-advance in Ireland and the Lower *Dryas* clay in Denmark, and its end is placed at about 10,000 B.C. The commencement of the deposition of the upper laminated clay is placed at 8,300 B.C., and its continuation for some four to five hundred years (estimated by counting the varves) is believed to be the result of a valley glaciation in the Lake District. This is correlated with the Antrim coast re-advance and valley glaciation in the Wicklow Mountains, the Upper *Dryas* clay of Denmark and the formation of the great Fenno-Scandian moraines. In the post-glacial period, a dating between 6,300 and 6,000 B.C. for the Boreal-Atlantic transition also agrees with Scandinavian results.

A brief correlation with the previous work is made and the greater detail revealed by pollen-analysis is demonstrated, while the same technique is also made to shed further light on the stratigraphical results previously obtained. H. G. BAKER

THE NORWEGIAN POLAR INSTITUTE

ON March 1, the Norwegian Polar Institute (Norsk Polarinstitutt) was established in Oslo in order to continue and expand the activity of Norges Svalbard- og Ishavs-undersøkelser. The latter office was founded in 1928, when it took over the work which since 1909 had been carried out by Government-supported expeditions to Svalbard. Norges Svalbard- og Ishavs-undersøkelser has been engaged in the preparation of topographic maps and hydrographic charts of the Svalbard region and in geological investigation on Svalbard. It has provided facilities for numerous scientific workers to visit Svalbard and Eastern Greenland, and has carried out a large amount of practical work such as the establishment of aids for navigation and maintenance of weather stations.

Besides continuing this work, the Polar Institute will broaden the scope of the scientific activity, partly by adding specialists of its own permanent staff, and partly by securing the collaboration of specialists who are connected with university institutions in Oslo and Bergen and other scientific organisations. The sphere of interest will be expanded to include the regions of the Antarctic over which Norway claims sovereignty. It is hoped that the Polar Institute will be able to undertake, sponsor or stimulate geological and palæontological research, glaciological and meteorological studies as well as work in the fields of zoology and botany. The publications of Norges Svalbard- og Ishavs-undersøkelser (*Skrifter* and *Meddelelser*) will be continued from the Polar Institute without any break in the numbering.

The Polar Institute will not absorb organisations which are primarily engaged in scientific work in the polar regions, such as the Aurora Observatory at Tromsö or the Government Institute of Whaling Research in Oslo; wherever desirable, it will collaborate with these organisations.

The Polar Institute comes under the Department of Industry of the Norwegian Government, but Dr. H. U. Sverdrup, who has been appointed director,

has also been attached to the University in Oslo. He will be able to accept special students at the Institute and thus to attract the attention of young men to the problems of the polar regions. Dr. Sverdrup, until this year professor of oceanography in the University of California and director of the Scripps Institute, has himself had a distinguished career as arctic explorer, oceanographer and mathematician. He is perhaps best known for his observations of the tidal currents over the Siberian Shelf made during the Norwegian expedition of the *Maud*, and for his two recent books—the part dealing with physical oceanography in "The Oceans" and his "Oceanography for Meteorologists", of which an edition has been published in Britain. He has taken an active and leading part in modern oceanographical research.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, June 21

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 8.30 p.m.—Dr. Isaiah Bowman: "The Geographical Relation of the U.S.A. to World Policies".

Monday, June 21—Friday, July 2

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1).—Conference on "Scientific Information Services".

Tuesday, June 22

ROYAL ANTHROPOLOGICAL INSTITUTE (joint meeting with the INTERNATIONAL AFRICAN INSTITUTE, at 21 Bedford Square, London, W.C.1), at 5 p.m.—Dr. K. L. Little: "The Secret Society as an Arbiter of Culture" (Discussion Meeting).

Wednesday, June 23—Friday, June 25

INSTITUTION OF THE RUBBER INDUSTRY (at Central Hall, Westminster, London, S.W.1).—Rubber Technology Conference.

Thursday, June 24

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir George Thomson, F.R.S.: "Nuclear Explosions" (Bakerian Lecture).

MINERALOGICAL SOCIETY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

Thursday, June 24—Friday, June 25

GENETICAL SOCIETY OF GREAT BRITAIN (joint meeting with the BRITISH EMPIRE CANCER CAMPAIGN, at the Royal Society of Medicine, 1 Wimpole Street, London, W.1).—Symposium on "The Genetics of Cancer".* (Afternoon Session on Thursday afternoon, at 2.30 p.m., at the Medical Society of London, 11 Chandos Street, London, W.1.)

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

DIRECTOR OF THE RESEARCH INSTITUTE OF LAUNDERERS, DRY-CLEANERS AND DYERS OF NEW ZEALAND—The Scientific Adviser, New Zealand Scientific Office, B.C.S.O., Africa House, Kingsway, London, W.C.2 (June 23).

READERSHIP IN BIOCHEMISTRY at University College—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 23).

ASSISTANT IN THE DEPARTMENT OF PHYSIOLOGY, a LECTURER IN CLINICAL CHEMISTRY, and a LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, The University, Aberdeen (June 25).

LECTURERS (3) IN THE CHEMISTRY DEPARTMENT, LECTURERS (2) IN THE PHYSICS DEPARTMENT, and a LECTURER IN THE CHEMICAL ENGINEERING DEPARTMENT—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11 (June 26).

SENIOR LECTURER IN MATHEMATICS—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (June 26).

LECTURERS (2) IN GEOLOGY—The Registrar, King's College, Newcastle-upon-Tyne (June 26).

ASSISTANT EXAMINERS IN THE PATENT OFFICE under the Board of Trade—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 45A (June 30).

GRASSLAND AGRONOMIST, and a PLANT BREEDER with training in mycology—The Director, Welsh Plant Breeding Station, Agricultural Research Building, Penglais, Aberystwyth (June 30).

LECTURER IN BOTANY in the United College, St. Andrews—The Secretary, The University, St. Andrews (June 30).

TUTORIAL RESEARCH STUDENTSHIP IN MATHEMATICS (Pure or Applied)—The Principal, Royal Holloway College, Englefield Green, Surrey (June 30).

ASSISTANT LECTURER OR LECTURER IN GEOLOGY—The Secretary, The University, Aberdeen (June 30).

LECTURER IN METALLOGRAPHY in the University of Melbourne—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (June 30).

PATENT OFFICERS under the Ministry of Supply—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 2175 (June 30).

RESEARCH FELLOWSHIPS IN MATHEMATICAL PHYSICS—The Secretary, The University, Edmund Street, Birmingham 1 (July 1).

RESEARCH AWARD IN THE DEPARTMENT OF PHYSICS—The Registrar, University College, Hull (July 2).

RESEARCH OFFICER IN THE DIVISION OF INDUSTRIAL CHEMISTRY for the investigation of relationships between the molecular structure and dielectric properties of electrical insulating materials—The Secretary, Australian Scientific Research Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 1701 (July 3).

COUNTY HORTICULTURAL INSTRUCTOR (male) on the staff of the Somerset Farm Institute, Cannington, Bridgwater—The Chief Education Officer, County Hall, Taunton (July 3).

HEAD OF THE DEPARTMENT OF AGRICULTURE, a HEAD OF THE DEPARTMENT OF VETERINARY SCIENCE, and a HEAD OF THE DEPARTMENT OF FORESTRY, at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (July 3).

PROFESSORSHIPS OF PHARMACOLOGY, ENTOMOLOGY, PROTOZOOLOGY, and PATHOLOGY and BACTERIOLOGY, at the School of Tropical Medicine, Calcutta—The High Commissioner for India, General Department, India House, Aldwych, London, W.C.2, quoting No. 4/26A (July 5).

LECTURER IN THE DEPARTMENT OF BOTANY, University of Cape Town—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (Cape Town, July 15).

PROFESSOR OF CIVIL ENGINEERING CONSTRUCTION AND FOUNDATIONS, a PROFESSOR OF STRENGTH OF MATERIALS, a PROFESSOR OF HYDRAULICS AND WATER POWER, a PROFESSOR OF STEEL BRIDGES AND METALLIC STRUCTURES, a PROFESSOR OF LINE TELEPHONY AND TELEGRAPHY, and a PROFESSOR OF ELECTRIC POWER STATIONS, at the Farouk I University, Alexandria—The Director, Egyptian Education Bureau, 4 Chesterfield Gardens, London, W.1 (July 15).

CHALLIS CHAIR OF HISTORY in the University of Sydney—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (July 31).

PROFESSOR OF MATHEMATICS AND HEAD OF THE DEPARTMENT, and a PROFESSOR OF MATHEMATICAL PHYSICS, in the University of Cape Town—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (July 31).

CHAIR OF ELECTRICAL ENGINEERING in the University of Sydney—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (Sydney, August 15).

LECTURER IN MATHEMATICS—The Registrar, The University, Reading.

PROFESSOR OF PHYSICS AND ELECTRICAL ENGINEERING, and a LECTURER IN APPLIED MECHANICS, at the Royal Naval College, Greenwich—The Director (P.A.), Education Department, Admiralty, London, S.W.1.

RESEARCH STATISTICIANS and ASSISTANT STATISTICIANS—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

LECTURER IN BOTANY, and a LECTURER IN ECONOMICS, at the Imperial College of Tropical Agriculture, Trinidad—The Secretary, Imperial College of Tropical Agriculture, Grand Buildings, Trafalgar Square, London, W.C.2.

LABORATORY ASSISTANT with experience of chemical and/or biochemical analysis—The Department of Veterinary Hygiene and Preventive Medicine, Royal (Dick) Veterinary College, Edinburgh.

SENIOR LECTURER and LECTURER IN PHYSICS in the University of Otago, Dunedin—The High Commissioner for New Zealand, 415 Strand, London, W.C.2.

PHYSICIST, and a CHEMIST—The Director of Research, British Rat and Allied Feltmakers' Research Association, Department of Textile Industries, The University, Leeds 2.

SENIOR TECHNICIAN IN THE PHARMACY AND BIOLOGY LABORATORIES—The Secretary, Royal Technical College, Glasgow.

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